AD-A102 720 NEW JERSEY DEPT OF ENVIRONMENTAL PROTECTION TRENTON --ETC F/G 13/13
NATIONAL DAM SAFETY PROGRAM. BETHANY HOLF DAM (NJ00798), DELAWA--ETC(U)
JUL 81 R J MCDERMOTT, J E GRIBBIN DACW61-79-C-0011
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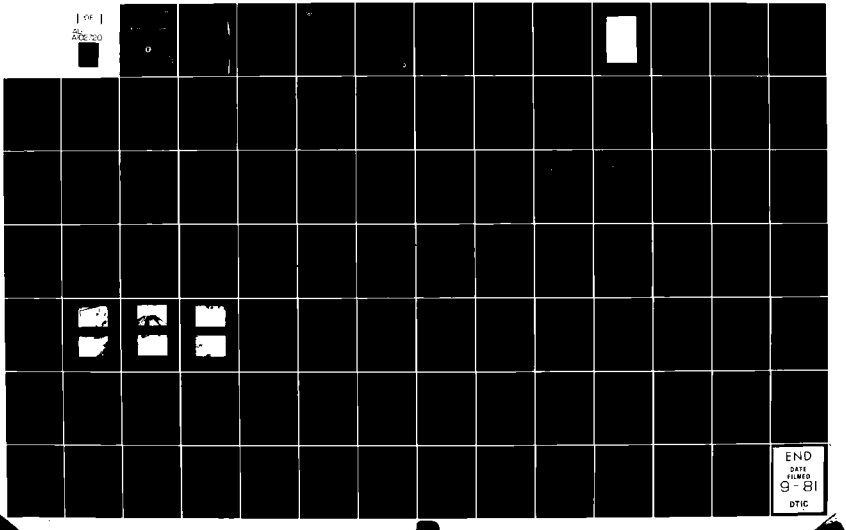

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DELAWARE RIVER BASIN
TRIBUTARY TO HAYNES CREEK
BURLINGTON COUNTY
NEW JERSEY

BETHANY HOLE DAM
NJ00798

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

DEPARTMENT OF THE ARMY
Philadelphia District
Corps of Engineers
Philadelphia, Pennsylvania

REPT No: DAEN/NAP-53842/NJ00798-81/07

JULY 1981

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

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National Dam Safety Program. Bethany Hole Dam (NJ00798), Delaware River Basin, Tributary to Haynes Creek, Burlington County, New Jersey. Phase I Inspection Report

18. SUPPLEMENTARY NOTES

Copies are obtainable from National Technical Information Service, Springfield, Virginia 22151.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dams	National Dam Safety Program	Spillways
Embankments	Bethany Hole Dam, NJ	Erosion
Visual Inspection	Delaware River Basin	
Structural Analysis	Haynes Creek, NJ	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report cites results of a technical investigation as to the dam's adequacy. The inspection and evaluation of the dam is as prescribed by the National Dam Inspection Act, Public Law 92-367. The technical investigation includes visual inspection, review of available design and construction records, and preliminary structural and hydraulic and hydrologic calculations, as applicable. An assessment of the dam's general condition is included in the report.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
CUSTOM HOUSE—2D & CHESTNUT STREETS
PHILADELPHIA, PENNSYLVANIA 19106

IN REPLY REFER TO
NAPEN-N

Honorable Brendan T. Byrne
Governor of New Jersey
Trenton, New Jersey 08621

31 JUL 1981

Dear Governor Byrne:

Inclosed is the Phase I Inspection Report for Bethany Hole Dam in Burlington County, New Jersey which has been prepared under authorization of the Dam Inspection Act, Public Law 92-367. A brief assessment of the dam's condition is given in the front of the report.

Based on visual inspection, available records, calculations and past operational performance, Bethany Hole Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillways are considered inadequate because a flow equivalent to 55 percent of the One Hundred Year Flood would cause the dam to be overtopped. To ensure adequacy of the structure, the following actions, as a minimum are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated.

b. Within six months from the date of approval of this report the owner should engage a qualified professional consultant to initiate a program to monitor the observed seepage on a periodic basis in order to detect any changes in condition.

c. Within six months from the date of approval of this report the following remedial actions should be initiated:

(1) The primary and secondary spillway discharge pipes should be cleaned of accumulated silt and debris.

NAPEN-N
Honorable Brendan T. Byrne

(2) Trees, adverse vegetation and debris on the embankment should be removed.

(3) Eroded areas on the embankment should be properly filled and stabilized.

(4) The downstream side of the embankment in the vicinity of the spillway culverts should be properly graded and stabilized.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam, within one year from the date of approval of this report.

e. An emergency action plan should be developed which outlines actions to be taken by the owner to minimize the downstream effects of an emergency at the dam within six months from the date of approval of this report.

A copy of the report is being furnished to Mr. Dirk C. Hofman, New Jersey Department of Environmental Protection, the designated State Office contact for this program. Within five days of the date of this letter, a copy will also be sent to Congressman Forsythe of the Sixth District. Under the provision of the Freedom of Information Act, the inspection report will be subject to release by this office, upon request, five days after the date of this letter.

Additional copies of this report may be obtained from the National Technical Information Services (NTIS), Springfield, Virginia 22161 at a reasonable cost. Please allow four to six weeks from the date of this letter for NTIS to have copies of the report available.

An important aspect of the Dam Inspection Program will be the implementation of the recommendations made as a result of the inspection. We accordingly request that we be advised of proposed actions taken by the State to implement our recommendations.

Sincerely,

ROGER L. BALDWIN
Lieutenant Colonel, Corps of Engineers
Commander and District Engineer

1 Incl
As stated

Copies furnished:
Mr. Dirk C. Hofman, P.E., Deputy Director
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

Mr. John O'Dowd, Acting Chief
Bureau of Flood Plain Regulation
Division of Water Resources
N.J. Dept. of Environmental Protection
P.O. Box CN029
Trenton, NJ 08625

BETHANY HOLE DAM (NJ00798)

CORPS OF ENGINEERS ASSESSMENT OF GENERAL CONDITIONS

This dam was inspected on 27 January 1981 by Storch Engineers, under contract to the State of New Jersey. The State, under agreement with the U.S. Army Engineer District, Philadelphia, had this inspection performed in accordance with the National Dam Inspection Act, Public Law 92-367.

Bethany Hole Dam, initially listed as a high hazard potential structure, but reduced to a significant hazard potential structure as a result of this inspection, is judged to be in fair overall condition. The dam's spillways are considered inadequate because a flow equivalent to 55 percent of the One Hundred Year Flood would cause the dam to be overtopped. To ensure adequacy of the structure, the following actions, as a minimum are recommended:

a. The spillway's adequacy should be determined by a qualified professional consultant engaged by the owner using more sophisticated methods, procedures and studies within six months from the date of approval of this report. Within three months of the consultant's findings remedial measures to ensure spillway adequacy should be initiated.

b. Within six months from the date of approval of this report the owner should engage a qualified professional consultant to initiate a program to monitor the observed seepage on a periodic basis in order to detect any changes in condition.

c. Within six months from the date of approval of this report the following remedial actions should be initiated:

(1) The primary and secondary spillway discharge pipes should be cleaned of accumulated silt and debris.

(2) Trees, adverse vegetation and debris on the embankment should be removed.

(3) Eroded areas on the embankment should be properly filled and stabilized.

(4) The downstream side of the embankment in the vicinity of the spillway culverts should be properly graded and stabilized.

d. The owner should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam, within one year from the date of approval of this report.

e. An emergency action plan should be developed which outlines actions to be taken by the owner to minimize the downstream effects of an emergency at the dam within six months from the date of approval of this report.

APPROVED: Roger L. Baldwin

ROGER L. BALDWIN
Lieutenant Colonel, Corps of Engineers
Commander and District Engineer

DATE: 31 July 81

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam:	Bethany Hole Dam, NJ00798
State Located:	New Jersey
County Located:	Burlington
Drainage Basin:	Delaware River
Stream:	Tributary to Haynes Creek
Date of Inspection:	January 27, 1981

Assessment of General Conditions of Dam

Based on visual inspection, past operational performance and Phase I engineering analyses, the dam is assessed as being in fair overall condition.

Based on investigations of the downstream flood plain made in connection with this report, it is recommended that the hazard potential classification be downgraded from high to significant hazard.

Hydraulic and hydrologic analyses indicate that the spillway is inadequate. Discharge capacity of the spillways is not sufficient to pass the designated spillway design flood (100-year storm) without an overtopping of the dam. The spillways, together with a low area in the lake shore adjacent to the dam, are capable of passing approximately 54 percent of the SDF. Therefore, the owner should in the near future engage a professional engineer experienced in the design and construction of dams to perform more accurate hydraulic and hydrologic analyses. Based on the findings of the analyses, the need for, and type of remedial measures should be determined and then implemented.

The owner should, in the near future, develop an emergency action plan together with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam.

The observed seepage should be monitored on a periodic basis by a professional engineer experienced in the design and construction of dams in order to detect any changes in condition.

In addition, it is recommended that the following remedial measures be undertaken by the owner in the near future:

1) The primary and secondary spillway discharge pipes should be cleaned of accumulated silt and debris.

2) Trees, adverse vegetation and debris on the embankment should be removed.

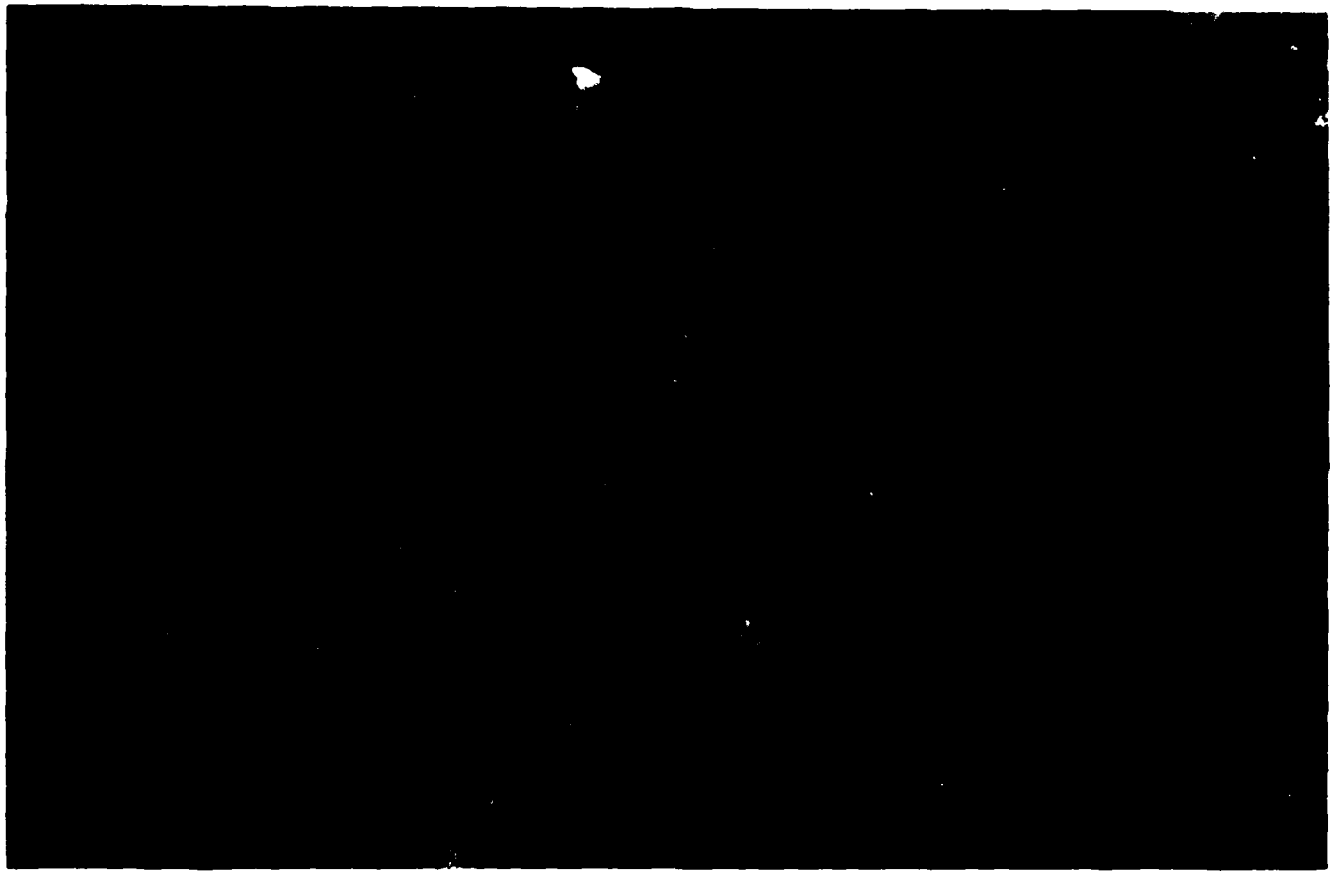
3) Eroded areas on the embankment should be properly filled and stabilized.

4) The downstream side of the embankment in the vicinity of the spillway culverts should be properly graded and stabilized.

In the future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam.

Richard J. McDermott, P.E.

John E. Gribbin, P. E.



OVERVIEW - BETHANY HOLE DAM

31 JANUARY 1981

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PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams, for Phase I Investigations. Copies of these guidelines may be obtained from the Office of Chief of Engineers, Washington, D.C. 20314. The purpose of a Phase I Investigation is to identify expeditiously those dams which may pose hazards to human life or property. The assessment of the general condition of the dam is based upon available data and visual inspections. Detailed investigation, and analyses involving topographic mapping, subsurface investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify any need for such studies.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. It is important to note that the condition of dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through continued care and inspection can there be any chance that the unsafe conditions be detected.

Phase I inspections are not intended to provide detailed hydraulic and hydrologic analyses. In accordance with the established Guidelines, the Spillway Test flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The test flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydraulic and hydrologic studies, considering the size of the dam, its general condition and the downstream damage potential.

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

BETHANY HOLE DAM, I.D. NJ00798

SECTION 1: PROJECT INFORMATION

1.1 General

a. Authority

Public Law 92-367, August 8, 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a National Program of Dam Inspection throughout the United States. The Division of Water Resources of the New Jersey Department of Environmental Protection (NJDEP) in cooperation with the Philadelphia District of the Corps of Engineers has been assigned the responsibility of supervising the inspection of dams within the State of New Jersey. Storch Engineers has been retained by the NJDEP to inspect and report on a selected group of these dams. The NJDEP is under agreement with the Philadelphia District of the Corps of Engineers.

b. Purpose of Inspection

The visual inspection of Bethany Hole Dam was made on January 27, 1981. The purpose of the inspection was to make a general assessment of the structural integrity and operational adequacy of the dam structure and its appurtenances.

1.2 Description of Project

a. Description

Bethany Hole Dam is an earth embankment with primary and secondary spillways. In addition, a low area of the lake shore adjacent to the right end of dam serves as an auxiliary spillway. The primary spillway consists of a stoplog controlled drop inlet which discharges through a 48-inch CMP which transversely penetrates the dam embankment. The primary spillway also acts as the outlet works for the dam. The secondary spillway consists of a 36-inch CMP high level outlet which transversely penetrates the dam.

An unpaved road is located on the crest of the dam embankment which has elevation 86.9, National Geodetic Vertical Datum (N.G.V.D.) The elevation of the primary spillway crest is 79.8 while that of the invert of the secondary spillway is 80.8 and that of the auxiliary spillway adjacent to the dam is 84.2. The overall length of the dam is 180 feet and its height is 11.4 feet.

b. Location

Bethany Hole Dam is located in Evesham Township, Burlington County, New Jersey. It impounds a recreational lake located within a private golf course known as Little Mill Country Club. Principal access to the dam is by a golf course roadway which transverses the dam crest and which can be entered from Hopewell Road. Discharge from the spillways of the dam flow directly into a tributary to Haynes Creek.

c. Size and Hazard Classification

The dam is classified in accordance with criteria presented in "Recommended Guidelines for Safety Inspection of Dams" published by the U.S. Army Corps of Engineers. Size categories consist of Small, Intermediate and Large while hazard categories are designated as Low, Significant and High.

Size Classification: Bethany Hole Dam is classified as "Small" size since its maximum storage volume is 190 acre-feet (which is less than 1000 acre-feet) and its height is 11.4 feet (which is less than 40 feet).

Hazard Classification: Visual inspection of the downstream flood plain of the dam together with breach analysis indicate that failure of the dam could partially inundate one dwelling located adjacent to Lost Lake about 600 feet downstream from the dam. Additional dwellings adjacent to Lost Lake and Van Dal Lake (further downstream) would not be inundated. However, the dams at Lost Lake and Van Dal Lake would be overtopped. It is not anticipated that more than a few lives would be lost. Accordingly Bethany Hole Dam is classified as "Significant" Hazard.

d. Ownership

Bethany Hole Dam is owned by the Little Mill Country Club, Inc., Hopewell Road, Marlton, New Jersey 08053.

e. Purpose of Dam

The purpose of the dam is the impoundment of a lake used for recreation and water supply for the golf course.

f. Design and Construction History

Reportedly, the tract of land upon which Bethany Hole Dam is constructed is known as "Little Mill." A mill constructed prior to the Revolutionary War located just downstream from the present dam was used during the war as an iron mill. In the late 1800's a timber dam was constructed for the purpose of maintaining cranberry bogs. Around 1970 the Little Mill Country Club, Inc. constructed the present dam which reportedly has a concrete core. In 1977 the high level 36-inch CMP secondary spillway was constructed.

g. Normal Operation Procedures

The dam and appurtenances are operated and maintained by the Little Mill Country Club, Inc. Repairs are made on an "as needed" basis.

1.3 Pertinent Data

a.	Drainage Area	2.5 square miles
b.	Discharge at Damsite	
	Maximum flood at damsite	Flood during 1940's (quantity of flow unknown)
	Outlet Works at pool elevation	84 cfs
	Primary and Secondary spillways at top of dam	218 cfs
	Auxiliary spillway at top of dam	883 c.f.s.
	Total discharge at top of dam	1101 c.f.s.

c. Elevation (N.G.V.D.)

Top of dam	86.9
Primary spillway crest	79.8
Maximum pool-design surcharge	87.7
Secondary spillway crest	81.5
Auxiliary spillway crest	84.2
Stream bed at toe of dam	75.5
Maximum tailwater	79 (Estimated)

d. Reservoir

Length of maximum pool	1000 feet (Estimated)
Length of recreation pool	500 feet (Scaled)

e. Storage (Acre-feet)

Recreation pool	32
Design surcharge	209
Top of dam	190

f. Reservoir Surface (acres)

Top of dam	24.9 (Estimated)
Maximum pool - design surcharge	25.3 (Estimated)
Recreation pool	21.1

g. Dam

Type	Earthfill
Length	180 feet
Height	11.4 feet
Sideslopes - Upstream	2 horiz. to 1 vert.
- Downstream	varies 1 horiz. to 2 vert. 2 horiz. to 1 vert.
Zoning	Unknown

Impervious core	Reportedly concrete corewall
Cutoff	Unknown
Grout curtain	Unknown

h. Principal Spillway

Type	Drop Inlet
Length of weir	16 feet
Crest Elevation	79.8 feet
Gates	Timber stoplogs
Approach channel	N.A.
Discharge channel	48-inch CMP

i. Secondary Spillway

Type	36-inch CMP
Length of weir	3 feet (diameter)
Crest elevation	81.5
Gates	N.A.
Approach channel	N.A.
Discharge channel	Outfalls into downstream channel

j. Auxiliary Spillway

Type	Irregular low area in lake shore adjacent to dam
Width	80 feet (approx.)
Crest Elevation	84.2 feet
Gates	N.A.
Approach Channel	No Distinct Channel
Discharge Channel	No Distinct Channel

k.	Regulating Outlet	Removable Stoplogs
l.	Diversion and Regulating Tunnel	N.A.

SECTION 2: ENGINEERING DATA

2.1 Design

No plans or calculations pertaining to the original design of the dam could be obtained.

2.2 Construction

No data or reports pertaining to the construction of the dam are available.

2.3 Operation

No data or reports pertaining to the operation of the dam are available.

2.4 Evaluation

a. Availability

No data or reports pertaining to the operations of the dam are available.

b. Adequacy

Available engineering data pertaining to Bethany Hole Dam is not adequate to be of significant assistance to the performance of a Phase I evaluation. A list of absent information is included in paragraph 7.1.b.

c. Validity

The validity of engineering data cannot be assessed due to the absence of data.

SECTION 3: VISUAL INSPECTION

3.1 Findings

a. General

The inspection of Bethany Hole Dam was performed on January 27, 1981 by staff members of Storch Engineers. A copy of the visual inspection check list is contained in Appendix 1. The following procedures were employed for the inspection:

1) The embankment of the dam, appurtenant structures and adjacent areas were examined.
2) The dam was measured and key elevations determined with the use of a surveyor's level.
3) The dam embankment, appurtenant structures and adjacent areas were photographed.
4) The downstream flood plain including two lakes was toured to evaluate downstream development and restricting structures.

b. Dam

The crest of the dam was somewhat irregular with a low lying area located beyond the right end of the embankment which appeared to act as an emergency or auxiliary spillway. The material used to construct the embankment appeared to be primarily sand.

The upstream face of the dam appeared to be somewhat irregular and was covered with grass and weeds. Some trees and stumps were also observed on the upstream side of the embankment. The trees ranged in size from 3 inches to 18 inches in diameter. The alignment or grading of the downstream face of the embankment was irregular. It appeared that the irregularity was due

in part to erosion and pedestrian activity. The downstream face was generally covered with grass, bushes and trees. The trees ranged in size from 2 inches to 18 inches in diameter. Heavy ground cover, consisting of briars, bushes and small trees, was observed just to the right of the spillway on the downstream face of the dam.

One wet spot was observed just below the downstream toe of the dam approximately 10 feet left of the downstream channel. No movement of water was observed. The elevation appeared to be approximately 1 foot higher than the water level in the stream which may be evidence of either seepage or emerging groundwater. No animal holes were observed on the embankment. The embankment in general, however, appeared to be very erodable. On the upstream side of the dam to the right of the spillway there was evidence of the dumping of debris.

In addition, a guide rail fence consisting of timber posts and a steel cable was observed along the upstream side of the crest of the dam. The fence is in a deteriorated condition. Some of the wooden posts were observed to be either missing or rotting.

c. Appurtenant Structures

The primary spillway consisted of a concrete drop inlet with the upstream side formed by timber stoplogs. Plywood forms on the outside of the drop inlet were still in place and the exposed concrete surfaces appeared to be somewhat spalled. At the time of inspection water was discharging across approximately 60% of the drop inlet due to the accumulation of debris which consisted of sticks, leaves, and grass. A pipe trash rack was observed on the upstream end of the primary spillway. Although the concrete surfaces were somewhat deteriorated the condition of the drop inlet appeared to be generally sound. The discharge

channel for the primary spillway is formed by a 48-inch CMP which transversely penetrates the dam embankment. The upstream end was obscured by discharge. The downstream invert of the 48-inch CMP was rusted, but the extent of deterioration of the invert could not be determined accurately. However, its condition appeared to be generally sound.

The secondary spillway consisted of a 36-inch CMP which transversely penetrated the dam and appeared to be in generally satisfactory condition. The pipe appeared to be more recent than the 48-inch CMP. Siltation was evident at the upstream end of the pipe and also near its center. The pipe appeared to be slightly misaligned. The 36-inch CMP secondary spillway pipe protruded approximately one to two feet from the middle of the downstream side of the embankment and discharged directly into the downstream channel. No headwall structures or any other type of support or embankment stabilization were observed at the outfalls of the 36-inch and 48-inch discharge pipes.

d. Downstream Channel

The downstream channel is a natural stream with a sandy bottom which meanders through a golf course and has banks approximately 1 foot high with relatively flat to moderate terrain beyond the banks. The terrain surrounding the channel is wooded in the area of the dam. A small waterwheel which appeared to be for decorative purposes was located approximately 200 feet downstream from the dam in the downstream channel. Reportedly, the original mill constructed in the 1700's was at this site. About 40 feet downstream from the waterwheel the channel enters a small pond by flowing through two corrugated metal pipes under an embankment. At the downstream end of the small pond, the channel continues by flowing through two more corrugated metal pipes into another pond known as Lost Lake located approximately 600 feet downstream from the dam.

e. Description of Reservoir Area

The reservoir consists of a small pond within the golf course. It is completely surrounded by grass slopes with some trees. The slopes appear to be of a moderate grade of about 5 to 10 percent, rising to a height of 8 to 20 feet above the water level. A small house or building was located on the right shore approximately 75 feet upstream from the dam. The building appeared to be a pump house, probably for an irrigation system associated with the golf course.

SECTION 4: OPERATIONAL PROCEDURES

4.1 Procedures

The level of water in the impoundment of subject dam is regulated by discharge over the timber stoplog controlled drop inlet. Reportedly, each year the stoplogs are removed and the lake is drawn down for maintenance purposes. The lake can be completely drawn down in approximately one day. Reportedly, the lake can be refilled in approximately three days.

Reportedly, the owner of the dam monitors the lake level by weather reports and visual observation and will lower the normal lake level by removing one or two stoplogs (6 to 12 inches) when periods of heavy rain are forecasted.

4.2 Maintenance of the Dam

Reportedly, maintenance of the dam is performed on an "as needed" basis. Sediment and accumulated debris are frequently removed from the spillway since the dam is used for water supply.

4.3 Maintenance of Operating Facilities

Reportedly, regular maintenance of operating facilities consists of cleaning the drop inlet and the spillway culvert pipes "as needed" and lowering of the lake each spring by the maintenance crew of the Little Mill Country Club.

4.5 Evaluation of Operational Adequacy

The operation of the dam has been successful to the extent that the present dam reportedly has never been overtopped. Reportedly, the

old dam may have overtopped in the 1940's during the flood that caused both Lost Lake and Van Dal Lake, located downstream, to breach. No records are available indicating the extent of damage caused by those breaches.

Maintenance documentation is poor and the maintenance program for the dam has not been adequate in the following areas:

1) Secondary spillway culvert pipe not properly cleaned of silt accumulation.
2) Debris accumulated around drop inlet not removed.
3) Trees and brush on the embankment not removed.
4) Eroded areas on the embankment not repaired.

SECTION 5: HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. Design Data

The quantity of storm water runoff that the spillway should be able to handle is based on the size and hazard classification of the dam. This runoff quantity, called the spillway design flood (SDF), is described in terms of return frequency or Probable Maximum Flood (PMF) depending on the extent of the dam's size and potential hazard. According to the "Recommended Guidelines for Safety Inspection of Dams" published by the U.S. Army Corps of Engineers, the SDF for Bethany Hole Dam falls in a range of 100-year frequency to 1/2 PMF. In this case, the low end of the range, 100-year frequency, is chosen since the factors used to select size and hazard classification are on the low side of their respective ranges.

The SDF peak computed for Bethany Hole Dam is 2023 c.f.s. This value is derived from the 100-year flood hydrograph computed by the use of the HEC-1-DAM Flood Hydrograph Computer Program using the Soil Conservation Service triangular unit hydrograph method with curvilinear transformation. Hydrologic computations and computer output are contained in Appendix 4.

The spillway discharge rates were computed by the use of weir formulae and the culvert capacity charts assuming inlet control appropriate for the spillway configuration. The total primary and secondary spillway discharge with lake level equal to the top of the dam was computed to be 218 c.f.s. Discharge through the auxiliary spillway (low area adjacent to dam) with lake level equal to the top of dam was computed to be 883 c.f.s. Therefore, total discharge with lake level equal to the top of dam was found to be 1101 c.f.s.

The SDF was routed through the dam by use of the HEC-1-DAM computer program using the modified Puls method. In routing the SDF, it was found that the dam crest would be overtopped by a depth of 0.8 foot. Accordingly, the subject spillway is assessed as being inadequate in accordance with criteria developed by the U.S. Army Corps of Engineers. A breach analysis was then performed assuming failure of the dam, and using a trapezoidal breach section with bottom length of 50 feet and sideslopes of 1 horizontal to 1 vertical. The breach peak outflow as computed to be 3885 c.f.s. Breach computations are contained in Appendix 4. The analysis indicated that failure of the dam could cause overtopping of the two downstream lakes and partial inundation of one dwelling located adjacent to one of the lakes.

b. Experience Data

Reportedly, the present dam has never been overtopped since construction in 1970. The previous timber dam may have been overtopped by the flood of record that occurred during the 1940's. During that flood, reportedly, the two dams located downstream were breached.

c. Visual Observation

No specific evidence of overtopping of the dam was observed at the time of inspection.

d. Overtopping Potential

As indicated in paragraph 5.1.a., a storm of magnitude equivalent to the SDF would cause overtopping of the dam by a height of 0.8 foot above the top of the dam. The spillways and low area adjacent to the dam are capable of passing approximately 54 percent of the SDF with lake level equal to the top of the dam.

e. Drawdown Data

Drawdown of the lake is accomplished by discharge through the 48" C.M.P. Total time for drawdown is estimated to be 10.2 hours (See Appendix 4).

SECTION 6: STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. Visual Observations

The dam appeared at the time of inspection to be outwardly structurally sound with no evidence of embankment cracks or distress. Observed evidence of seepage was not considered to be an indication of immediate embankment instability.

b. Generalized Soils Description

The generalized soils description of the dam site consists of recent alluvium deposited in poorly drained swampy conditions along stream courses overlying stratified deposits mostly of marine origin. The stratified deposits are composed predominantly of silty sand and narrowly graded sand. Depth to bedrock is greater than 100 feet.

c. Design and Construction Data

The analysis of structural stability and construction data for the dam is not available.

d. Operating Records

No operating records are available for the dam. Reportedly, the water level of the impoundment is monitored by the visual observations of the owner.

e. Post-Construction Changes

Reportedly, the only post-construction changes that have been made since the dam was constructed in 1970 was the installation of the secondary spillway (36-inch CMP) in 1977.

f. Seismic Stability

Bethany Hole Dam is located in Seismic Zone 1 as defined in "Recommended Guidelines for Safety Inspection of Dams" which is a zone of very low seismic activity. Experience indicates that dams in Seismic Zone 1 will have adequate stability under seismic loading conditions if they have adequate stability under static loading conditions. Bethany Hole Dam appeared to be generally stable under static loading conditions at the time of inspection.

SECTION 7: ASSESSMENT AND RECOMMENDATIONS

7.1 Dam Assessment

a. Safety

Based on hydraulic and hydrologic analyses outlined in Section 5 and Appendix 4, the spillways of Bethany Hole Dam are assessed as being inadequate. The spilllways are not able to pass the SDF without an overtopping of the dam.

The embankment appeared at the time of inspection to be outwardly stable.

b. Adequacy of Information

Information sources for this report include 1) field inspection, 2) USGS quadrangle, and 3) consultation with personnel of the Little Mill Country Club, Inc. The information obtained is sufficient to allow a Phase I assessment as outlined in "Recommended Guidelines for Safety Inspection of Dams."

Some of the absent data are as follows:

1. Construction and as-built drawings.
2. Description of fill material for embankment.
3. Design computations and reports.
4. Maintenance documentation.
5. Soils report for the site.

c. Necessity for Additional Data/Evaluation

Although some data pertaining to Bethany Hole Dam are not available, additional data are not considered imperative for this Phase I evaluation.

7.2 Recommendations

a. Remedial Measures

Based on hydraulic and hydrologic analyses oulined in paragraph 5.1.a., the spillways are assessed as being inadequate. It is therefore recommended that a professional engineer experienced in the design and construction of dams be engaged in the near future to perform more accurate hydraulic and hydrologic analyses. Based on the findings of these analyses, the need for and type of remedial measures should be determined and then implemented.

The owner should, in the near future, develop an emergency action plan together with an effective warning system outlining actions to be taken by the operator to minimize downstream effects of an emergency at the dam.

In addition, it is recommended that the following remedial measures be undertaken by the owner in the near future:

1) The primary and secondary spillway discharge pipes should be cleaned of accumulated silt and debris.

2) Trees, adverse vegetation and debris on the embankment should be removed.

3) Eroded areas on the embankment should be properly filled and stabilized.

4) The downstream side of the embankment in the vicinity of the spillway culverts should be properly graded and stabilized.

b. Maintenance

In the future, the owner of the dam should develop written operating procedures and a periodic maintenance plan to ensure the safety of the dam.

c. Additional Studies

The observed seepage should be monitored on a periodic basis by a professional engineer experienced in the design and construction of dams in order to detect any changes in condition.

PLATES

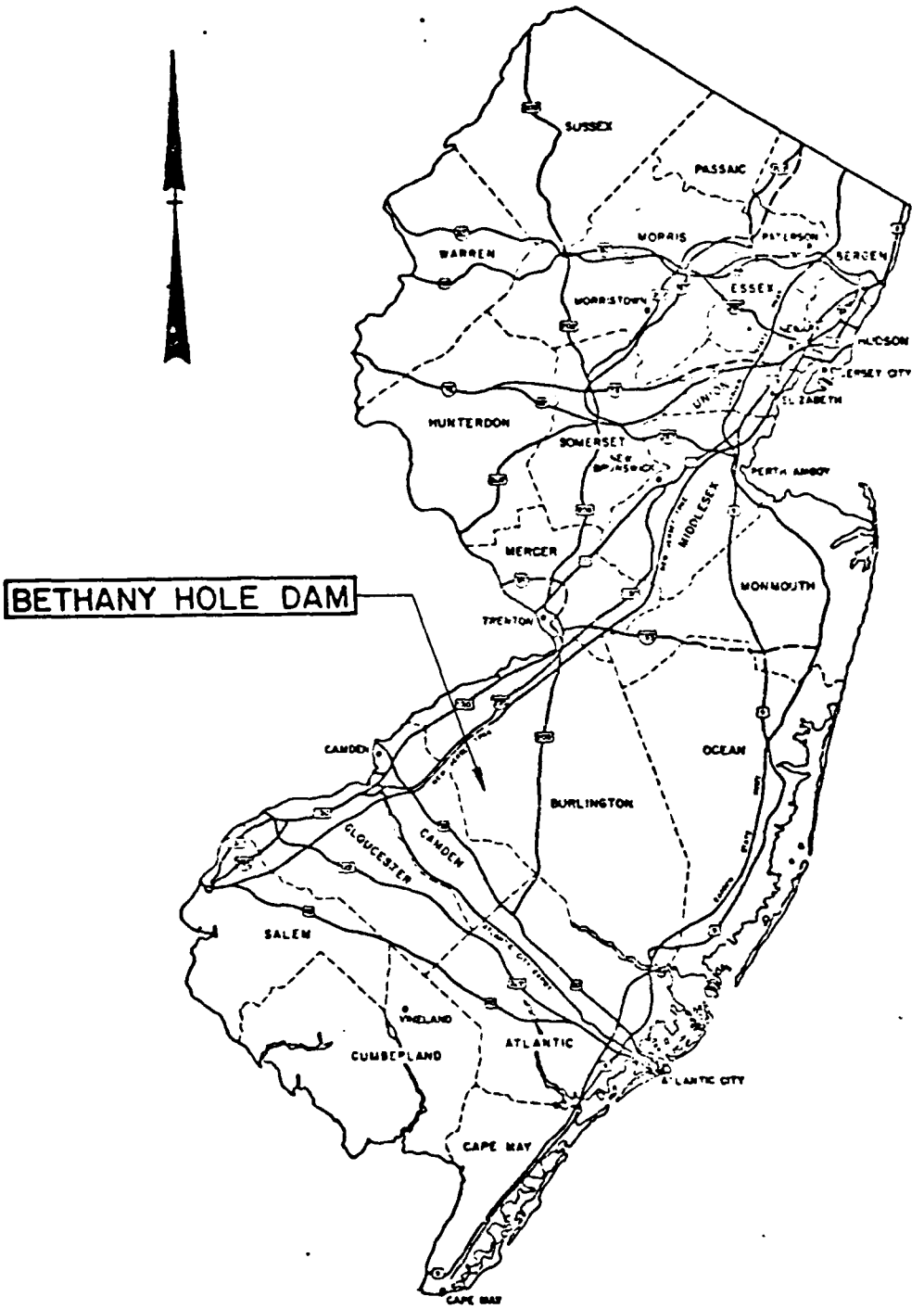


PLATE 1

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS KEY MAP BETHANY HOLE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00798 — SCALE: NONE DATE: FEB. 1981

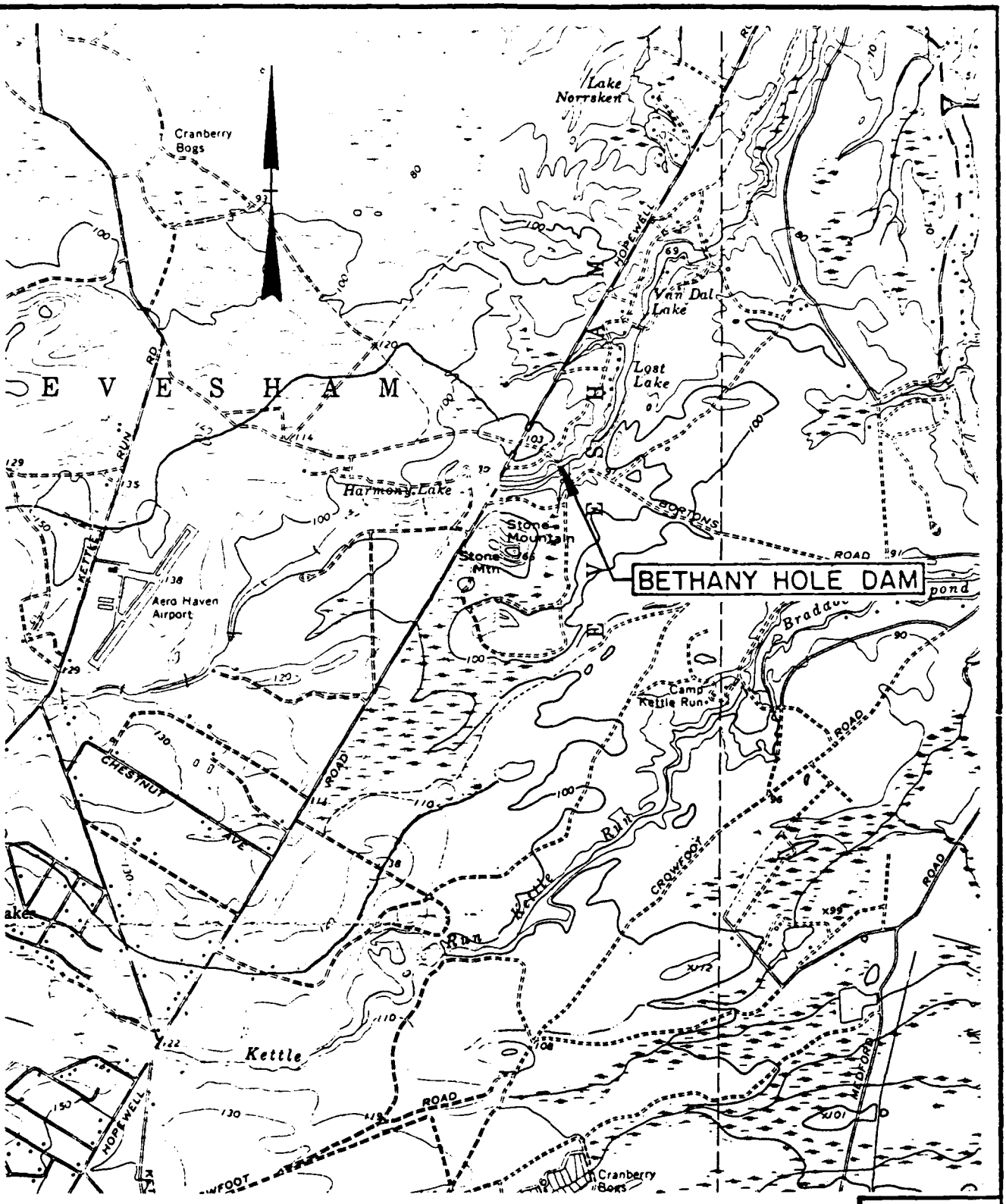
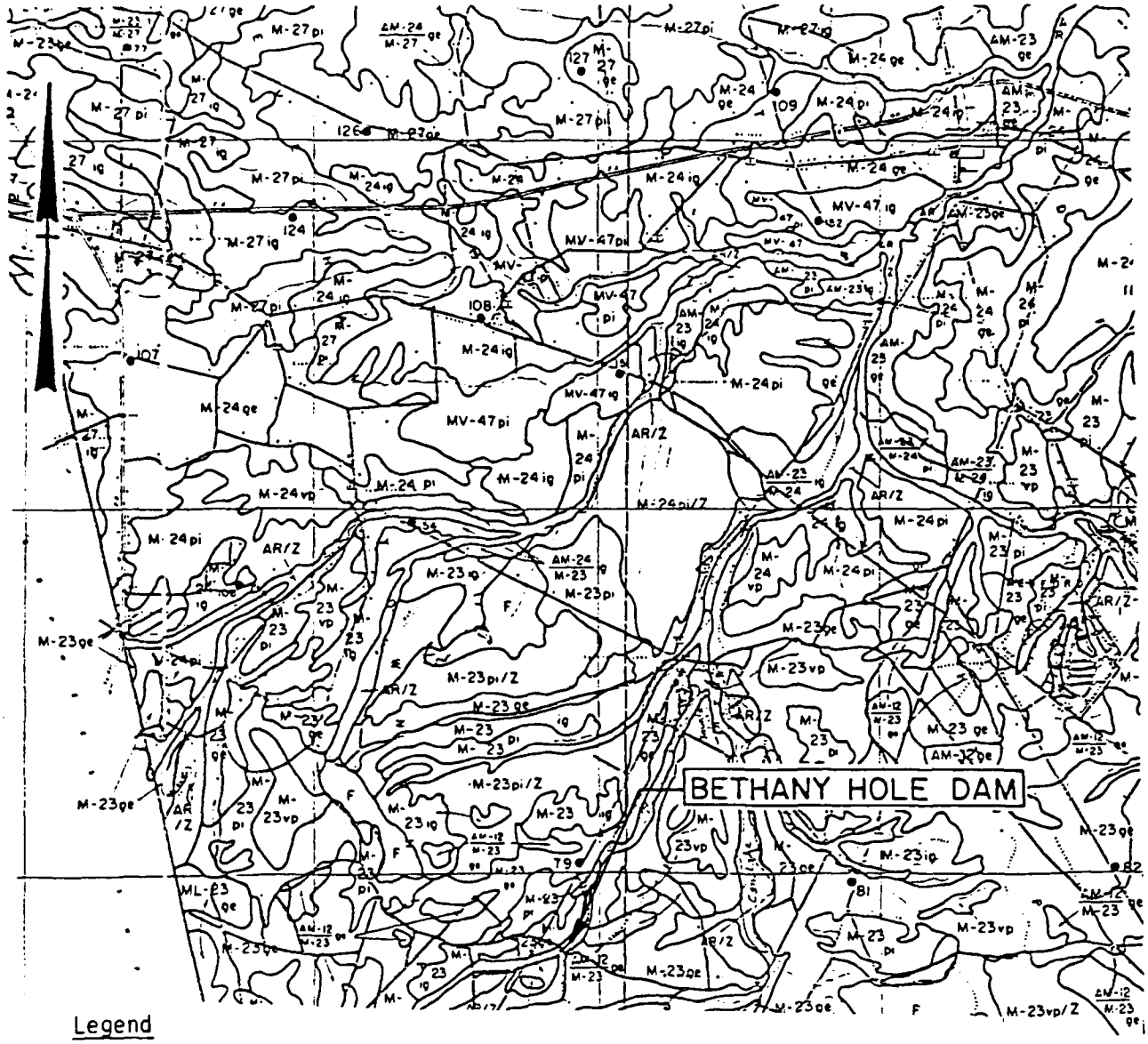


PLATE 2

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS VICINITY MAP BETHANY HOLE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00798 — SCALE: NONE DATE: FEB. 1981.



Legend

M-23 Stratified deposits mostly of marine origin

AM-12 A discontinuous, variable mantle of stratified, alluvial materials.

AR/Z Recent alluvium deposited in poorly drained swampy conditions along stream courses.

Note: Information taken from Rutgers University, Soil Survey of New Jersey, Report No. 20, Burlington County, May 1955 and Geologic Map of New Jersey prepared by J.V. Lewis and H. Kummel 1910-1912, revised by H, B. Kummel 1931 and M. Johnson 1950.

PLATE 3

STORCH ENGINEERS
FLORHAM PARK, NEW JERSEY.

DIVISION OF WATER RESOURCES
N.J. DEPT. OF ENVIR. PROTECTION
TRENTON, NEW JERSEY.

INSPECTION AND EVALUATION OF DAMS

SOIL MAP

BETHANY HOLE DAM

I.D. N.J. 00798

SCALE: NONE

DATE: FEB. 1981

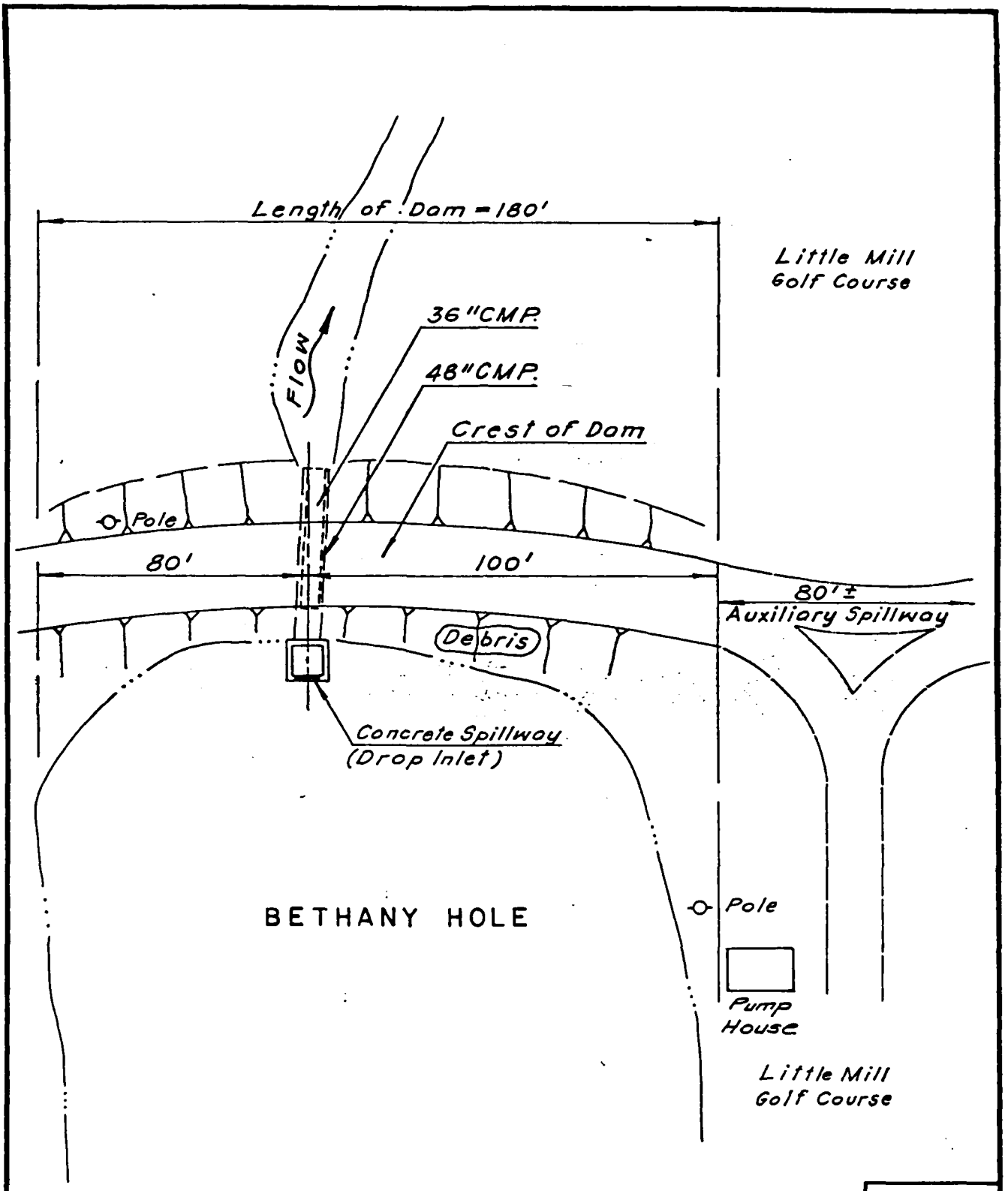
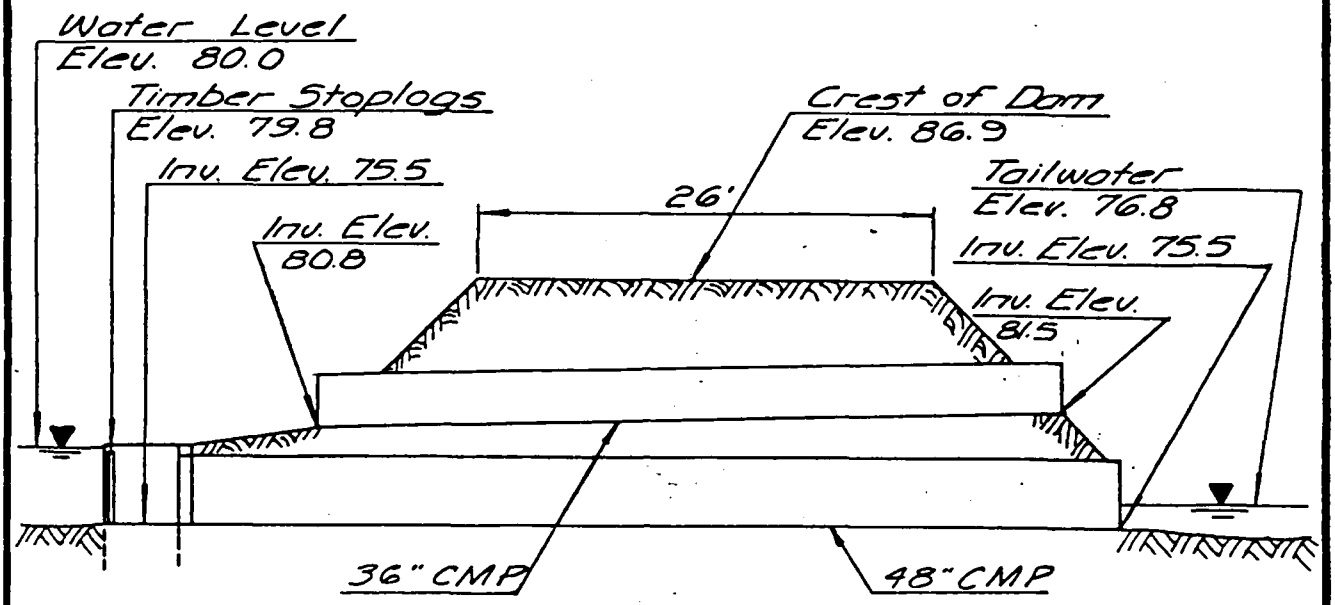
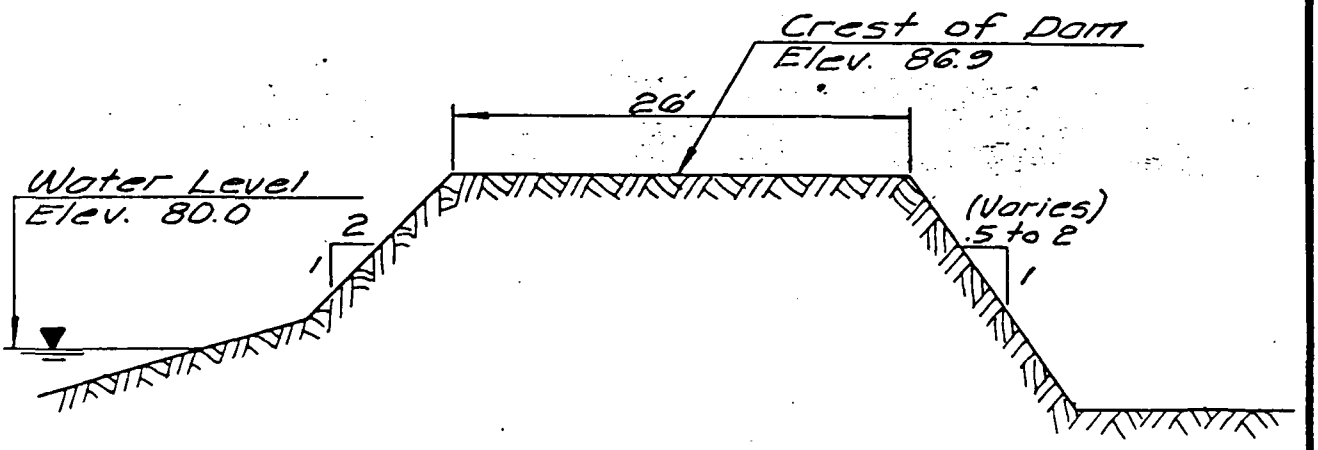


PLATE 4

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS GENERAL PLAN BETHANY HOLE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00798 — SCALE: NONE DATE: FEB. 1981



SPILLWAY SECTION



TYPICAL DAM SECTION

PLATE 5

STORCH ENGINEERS FLORHAM PARK, NEW JERSEY	INSPECTION AND EVALUATION OF DAMS SECTIONS BETHANY HOLE DAM
DIVISION OF WATER RESOURCES N.J. DEPT. OF ENVIR. PROTECTION TRENTON, NEW JERSEY	I.D. N.J. 00798 — SCALE: NONE DATE: MARCH, 1981

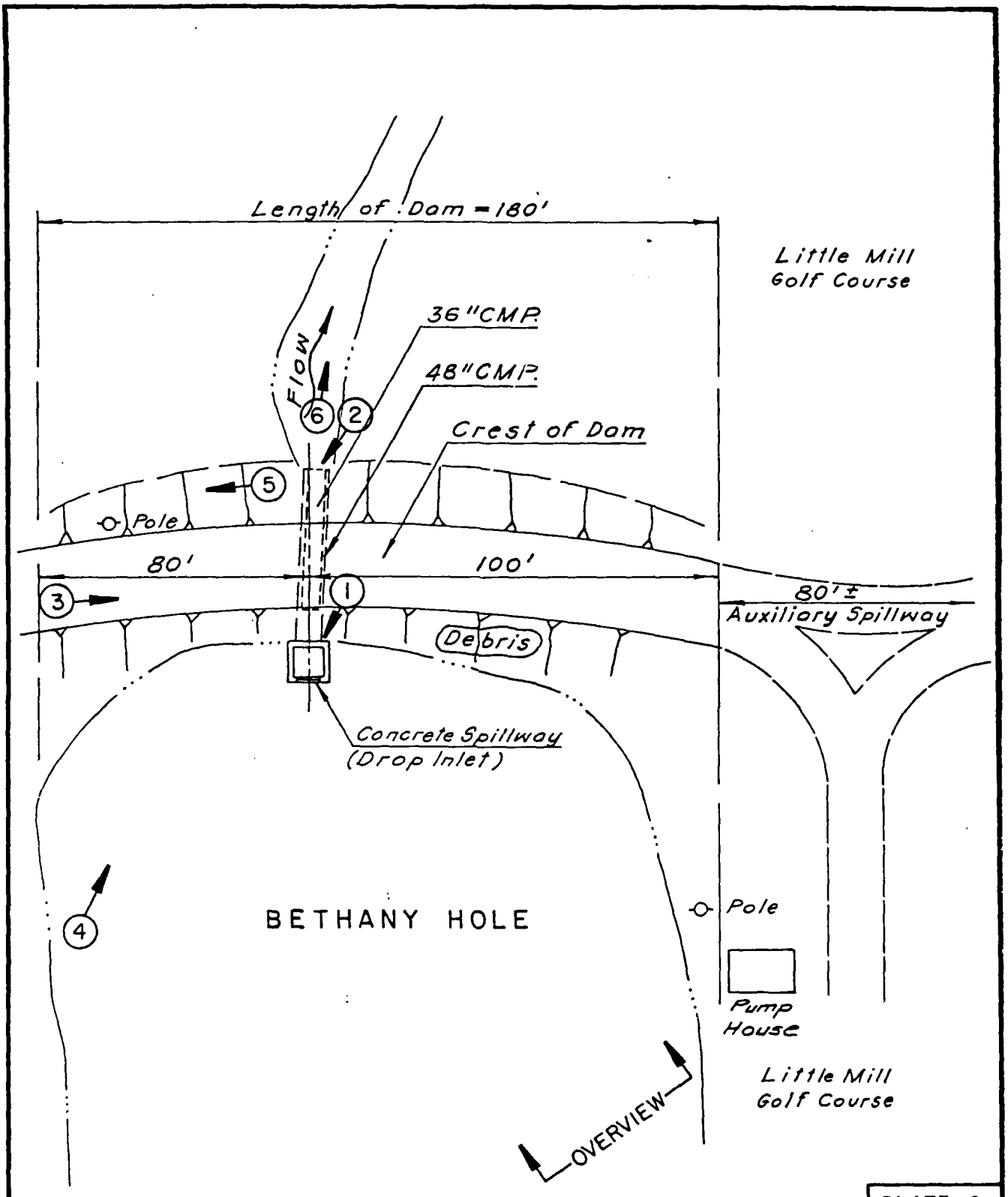


PLATE 6

STORCH ENGINEERS
FLORHAM PARK, NEW JERSEY

DIVISION OF WATER RESOURCES
N.J. DEPT. OF ENVIR. PROTECTION
TRENTON, NEW JERSEY

INSPECTION AND EVALUATION OF DAMS

PHOTO LOCATION PLAN
BETHANY HOLE DAM

I.D. N.J. 00798

SCALE: NONE

DATE: FEB. 1981

APPENDIX 1

Check List - Visual Inspection

Check List - Engineering Data

Check List

Visual Inspection

Phase I

Name of Dam Bethany Hole Dam County Burlington State N.J. Coordinators NJDEP

Date(s) Inspection 1/27/81 Weather P. Sunny Temperature 40°F.

Pool Elevation at time of Inspection 80.0 M.S.L. Tailwater at Time of Inspection 76.8 M.S.L.

Inspection Personnel:

John Gribbin Richard McDermott

Charles Osterkorn

Daniel Buckelew

John Gribbin Recorder

Owner not present.

EMBANKMENT

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
GENERAL	Unpaved roadway on crest appeared excessively erodable. Upstream and downstream sides covered with grass, bushes and trees (2" to 18"). Dumped debris observed on upstream face.	Trees and adverse vegitation should be removed. Debris should be removed.
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	Appeared sound.	
ANY NOTICEABLE SEEPAGE	Wet area observed at toe about 10' left of the downstream channel. No movement of water observed.	Origin of wet area could not be assessed. It could be seepage or ground water.
STAFF GAGE AND RECORDER	None observed.	
DRAINS	None observed.	

EMBANKMENT

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed.	
UNUSUAL MOVEMENT OR CRACKING AT OR BEYOND THE TOE	None observed.	
SLOUGHING OR EROSION OF EMBANKMENT AND ABUTMENT SLOPES	None observed.	
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Vertical: generally level. Horizontal: slightly curved. Side slopes irregular. Downstream slope in vicinity of spillway excessively steep.	
RIPRAP	None observed.	

OUTLET WORKS

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE SURFACES IN OUTLET CONDUIT	Same as primary spillway.	
INTAKE STRUCTURE	N.A.	
OUTLET STRUCTURE	N.A.	
OUTLET CHANNEL	Same as primary spillway.	
GATE AND GATE HOUSING	Timber stoplogs in primary spillway structure.	

PRIMARY SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
WEIR	Timber stoplogs forming portion of weir appeared to be in satisfactory condition. Three walls of concrete drop inlet form remainder of weir. Part of timber form work was observed. Quality of concrete appeared fair with aggregate exposed. Structure was generally sound. Debris was accumulated along a portion of the drop inlet.	Debris should be removed.
APPROACH CHANNEL	N.A.	
DISCHARGE CULVERT	CMP was rusted but appeared sound. However, invert of pipe could not be observed due to tailwater.	

SECONDARY SPILLWAY

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
WEIR	N.A.	
APPROACH CHANNEL	N.A.	
DISCHARGE CHANNEL	CMP appeared to be relatively recently installed. Its condition appeared satisfactory. Culvert was slightly misaligned.	Cause of misalignment could not be assessed. Cause could be differential settlement or improper placement.

INSTRUMENTATION

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
MONUMENTATION/SURVEYS	None observed.	
OBSERVATION WELLS	None observed.	
WEIRS	None observed.	
PIEZOMETERS	None observed.	
OTHER		

RESERVOIR

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SLOPES	Shore slopes grassed with moderate grade, 5% to 10%. A portion of the shore adjacent to the right end of dam was lower than the crest of dam creating an area of outflow from the lake serving as an auxiliary spillway.	
SEDIMENTATION	Unknown.	
STRUCTURES ALONG BANKS	Small pump house was located along the right shore near the dam.	

DOWNSTREAM CHANNEL

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTION, DEBRIS, ETC.)	Natural stream meandering through golf course. No debris was observed. Channel flows through a decorative waterwheel and through culverts in about 2 locations throughout the golf course. The waterwheel and culvert comprise obstructions.	
SLOPES	Banks approx. 1' high with flat to moderate rolling terrain beyond banks.	
STRUCTURES ALONG BANKS	Several dwellings located along two lakes located about 1500' and 3500' downstream.	

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

ITEM			REMARKS
DAM	-	PLAN	Not Availble
		SECTIONS	
SPILLWAY	-	PLAN	Not Available
		SECTIONS	
		DETAILS	
OPERATING EQUIPMENT PLANS & DETAILS			Not Available
OUTLETS	-	PLAN	Not Available
		DETAILS	
		CONSTRAINTS	
		DISCHARGE RATINGS	
HYDRAULIC/HYDROLOGIC DATA			Not Available
RAINFALL/RESERVOIR RECORDS			Not Available
CONSTRUCTION HISTORY			Not Available
LOCATION MAP			Not Available

ITEM	REMARKS
DESIGN REPORTS	Not Available
GEOLOGY REPORTS	Not Available
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM INSTABILITY SEEPAGE STUDIES	Not Available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	Not Available
POST-CONSTRUCTION SURVEYS OF DAM	Not Available
BORROW SOURCES	Not Available

ITEM	REMARKS
MONITORING SYSTEMS	Not Available
MODIFICATIONS	High level 36" CMP outlet reportedly constructed in 1977.
HIGH POOL RECORDS	Flood of Sept. 1, 1940 (record flood)- max. stage unknown.
POST CONSTRUCTION ENGINEERING STUDIES AND REPORTS	Not Available
PRIOR ACCIDENTS OR FAILURE OF DAM DESCRIPTION REPORTS	Reportedly, flood of Sept. 1, 1940 caused dam failure.
MAINTENANCE OPERATION RECORDS	Not Available

APPENDIX 2

Photographs

PHOTO 1
PRIMARY SPILLWAY

PHOTO 2
DOWNSTREAM ENDS OF PRIMARY AND SECONDARY SPILLWAYS

BETHANY HOLE DAM
27 JANUARY 1981

PHOTO 3
CREST OF DAM

PHOTO 4
UPSTREAM SIDE OF DAM AND SECONDARY SPILLWAY

BETHANY HOLE DAM
27 JANUARY 1981

PHOTO 5
DOWNSTREAM SIDE OF DAM

PHOTO 6
DOWNSTREAM CHANNEL

BETHANY HOLE DAM
27 JANUARY 1981

APPENDIX 3

Engineering Data

CHECK LIST

HYDROLOGIC AND HYDRAULIC DATA

ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: Wooded, relatively flat

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 80.0 (32 acre-feet)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): N.A.

ELEVATION MAXIMUM DESIGN POOL: 87.7

ELEVATION TOP DAM: 86.9

PRINCIPAL SPILLWAY CREST: Concrete Drop Inlet with stoplogs

a. Elevation 79.8

b. Type Broad crested weir (inlet walls) and sharp crested weir (stoplogs)

c. Width 1.0 ft. (broad crested weir), 0.2 ft. (sharp crested weir)

d. Length 9 ft. (broad crested weir), 3.5 ft. (sharp crested weir)

e. Location Spillover Upstream side of dam

f. Number and Type of Gates One set of stoplogs

AUXILIARY SPILLWAY CREST: Culvert Pipe

a. Elevation 81.5

b. Type 36-inch CMP

c. Width N.A.

d. Length N.A.

e. Location Spillover Downstream face of dam

f. Number and Type of Gates None

OUTLET WORKS: Included in spillway structure

a. Type Timber Stoplogs

b. Location Upstream end of drop inlet

c. Entrance Invert 75.5

d. Exit Invert 75.5

e. Emergency Draindown Facilities: Remove stoplogs

HYDOMETEOROLOGICAL GAGES: None

a. Type N.A.

b. Location N.A.

c. Records N.A.

MAXIMUM NON-DAMAGING DISCHARGE:

(Lake Stage Equal to Top of Dam) 1101 c.f.s. (including outflow over low area adjacent to dam.)

218 c.f.s. (spillways alone)

APPENDIX 4

Hydraulic/Hydrologic Computations

STORCH ENGINEERS

Project 1132-06 BETHANY HOLE DAM

Sheet 1 of 21

Made By JHH Date 3-18-81

Chkd By JG Date 4/3/81

HYDROLOGY:

HYDROLOGIC ANALYSIS

THE RUNOFF HYDROGRAPH WILL BE DEVELOPED BY THE HEC-1-DAM COMPUTER PROGRAM USING THE SCS-UNIT HYDROGRAPH METHOD WITH CURVILINEAR TRANSFORMATION.

DRAINAGE AREA = 2.5 SQMI

INFILTRATION DATA

INITIAL INFILTRATION = 1.5 IN

CONSTANT INFILTRATION = 0.15 IN/HR

TIME OF CONCENTRATION

1. [by SCS-TR 55]

OVERLAND FLOW:

LENGTH	=	4500	[ft]
AVE. SLOPE	=	1.88	[%]
$\Delta H = 210' - 125' = 85'$			
AVE. VELOCITY	=	0.34	[F.p.s]

CHANNEL FLOW:

LENGTH	=	9000	[ft]
AVE. SLOPE	=	0.5	[%]
$\Delta H = 125' - 80' = 45'$			
AVE. VELOCITY	=	2.07	[F.p.s]

$$T_c = \left[\left(\frac{4500}{0.34}\right) + \left(\frac{9000}{2.07}\right)\right]\frac{1}{3600} = 3.68 + 1.2$$

$T_c = 4.9$ Hr.

2. ['Handbook of hydrology' by Chow - Pg 14-36]

$$T_c = \sqrt[2.14]{2/3\, L\, n/\sqrt{S}}$$

$$T_c = \sqrt[2.14]{\frac{2/3\,(4500 \times 0.4)}{\sqrt{0.005}}} = 95 \text{ min}$$

T_c = time of concentration [min]
S = slope [%]
n = 0.4 roughness coefficient
L = length of overland flow [Ft]

$T_c = 1.6 + 1.2 = 2.8$ Hr

3. [by "Design of small dams" Pg 71]

$$T_c = \left(\frac{11.9(L)^3}{H}\right)^{0.385}$$

$$T_c = \left(\frac{11.9(2.56)^3}{130}\right)^{0.385}$$

T_c = time of concentration [Hr.]

L = longest water course [Mi]

H = elev. difference [Ft]

$T_c = 1.2$ Hr

$L = 2.56$ [Mi]

$H = 130$ [Ft]

COMPUTER INPUT

$T_c = 3.2$ Hr. LAG = 60%

LAG Time = 1.9 Hr.

PRECIPITATION

24 HOURS, 100 YEAR RAINSTORM DISTRIBUTION FOR BETHANY HOLE DAM

TIME [HR]	RAIN [IN]
1	.08
2	.08
3	.08
4	.08
5	.08
6	.08
7	.09
8	.09
9	.18
10	.18
11	.18
12	.19
13	.30
14	.30
15	.80
16	3.00
17	.40
18	.30
19	.19
20	.18
21	.09
22	.09
23	.08
24	.08
24 [Hr]	Σ 7.2 [IN]

From U.S. WEATHER BUREAU TP. 40

LAKE STORAGE VOLUME

W.S. ELEV. [Ft]	AREA [Acres]
75.5	0
80.0	21.1
90.0	26.6
100.0	260.0

HEC-1-DAM COMPUTER PROGRAM WILL DEVELOP STORAGE CAPACITY FROM WATER SURFACE AREAS & ELEVATIONS.

INFORMATION TAKEN FROM U.S.G.S QUAD-RANGLE Clementon & Medford Lakes, N.J.

HYDRAULICS

SPILLWAY DISCHARGE

THE SPILLWAY AT THE BETHANY HOLE DAM CONSISTS OF A PRIMARY SPILLWAY AT ELEV. 79.8 FEET, A SECONDARY SPILLWAY AT ELEV. 81.5 FEET & AN AUXILIARY SPILLWAY ADJACENT TO THE RIGHT END OF DAM AT ELEV. 84.3 FEET.

THE PRIMARY SPILLWAY IS A CONCRETE DROP INLET WITH TIMBER STOPLOGS FITTED IN THE UPSTREAM SIDE. THE DROP INLET DISCHARGES INTO A 48" CMP TRANSVERSELY PENETRATING THE DAM

THE SECONDARY SPILLWAY IS A 36" CORRUGATED METAL CULVERT TRANSVERSELY PENETRATING THE DAM.

THE AUXILIARY SPILLWAY CONSISTS OF A LOW AREA IN THE LAKE SHORE LOCATED ADJACENT TO THE RIGHT END OF DAM.

IT HAS AN IRREGULAR CROSS-SECTION

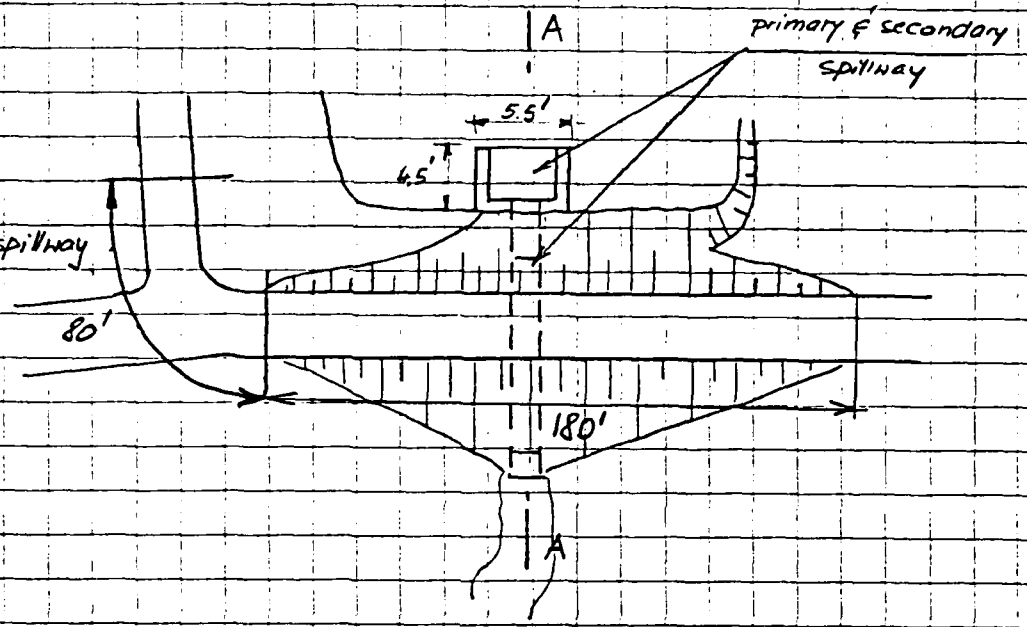
STORCH ENGINEERS

Sheet 7 of 21

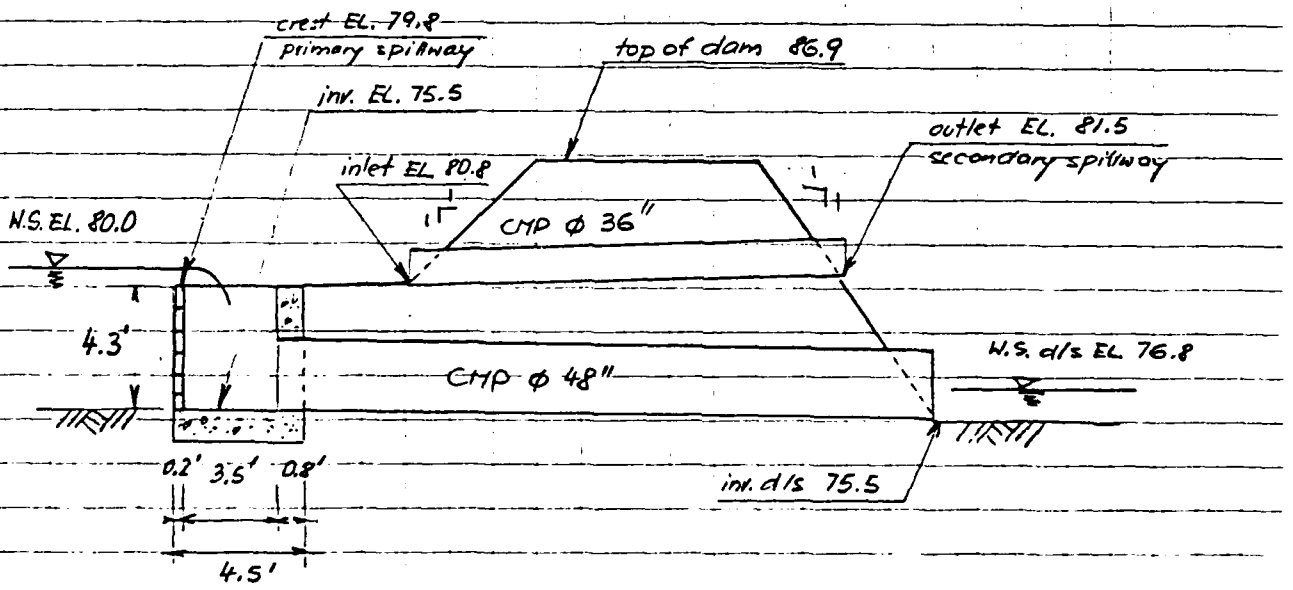
Project 1132-06 BETHANY HOLE DAM Made By JHQ Date 3-19-81

Chkd By JG Date 4/3/81

PLAN



ELEVATION SECTION A-A



STORCH ENGINEERS

Sheet 8 of 21

Project 1132-06 BETHANY HOLE DAM Made By JiHa Date 3-19-81

Chkd By JG Date 4/3/81

DISCHARGE CALCULATION

[Handbook of hydraulics - Pg 5-26]

THE DISCHARGE AT THE PRIMARY SPILLWAY WILL BE CALCULATED FROM ELEV. 79.8 FEET TO ELEV. 81.0 FOR THREE SIDES USING FORMULA FOR BROAD CRESTED WEIR

$$Q = C\,L\,H^{3/2}$$

Q = discharge [cfs]
C = coefficient of discharge
L = effective length of spillway [Ft]
H = total head on spillway [Ft]

[Handbook of hydraulics - Pg 5-9]

AND FOR ONE SIDE USING FORMULA FOR SHARP CRESTED WEIR

$$Q = C_e\,L\,H_e^{3/2}$$

Q = discharge [cfs]
$C_e = 3.22 + 0.44\,\frac{H}{P}$ coefficient
H = head [Ft]
P = high of weir [Ft]
L = effective length of spillway
$H_e = H + 0.004$
H = head on spillway [Ft]

[Handbook of hydraulics Pg 4-5]

FROM ELEV. 81.0 FEET AND ABOVE USING FORMULA FOR SUBMERGED ORIFICE FOR DIFFERENT HEADS, ORIFICE IS TAKEN TO BE OPENING OF DROP INLET

$Q = Ca\sqrt{2g\Delta h}$

Q = discharge [cfs]
C = coefficient of discharge
a = discharge area [Ft²]
g = 32.2
Δh = head above orifices [Ft]

[HEC Highway Culverts Pg 5-25]

THE DISCHARGE AT THE SECONDARY SPILLWAY WILL BE CALCULATED FROM ELEV. 81.5 AND ABOVE USING INLET CONTROL NOMOGRAPH

[Hand book of hydraulics Pg 5-25]

THE DISCHARGE AT AUXILIARY SPILLWAY WILL BE CALCULATED FROM ELEV. 84.3 FEET AND ABOVE USING FORMULA FOR BROAD CRESTED WEIR

$Q = CLH^{3/2}$

Q = discharge [cfs]
C = coefficient of discharge
L = eff. length of spillway [Ft]
H = total head on spillway [Ft]

STORCH ENGINEERS

Project 1132-06 BETHANY HOLE DAM Made By JHB Date 3-19-81

Chkd By JG Date 4/3/81

Sheet 10 of 21

BETHANY HOLE SPILLWAYS STAGE DISCHARGE TABULATION

W.L. ELEV. [Ft]	PRIMARY SPILLWAY EL. 79.8 — weir broad cr. L = 9' W = 1'			weir sharp cr. L = 3.5' P = 4.3' H = .2'			Weir Q_W [cfs]	orifice a = 12.25 Ft² C = .614			SECONDARY S. CMP ϕ 36° EL. 81.5 D = 2'		AUXILIARY SD. Weir broad cr. EL. 84.2 L = 80'			Total $(Q_1+Q_2+Q_3)$
	H [Ft]	C	Q [cfs]	H_c [Ft]	C_c	Q [cfs]		Δh [Ft]	Q [cfs]	Q_1 [cfs]	HW [Ft]	Q_2 [cfs]	H [Ft]	C	Q_3 [cfs]	Σ Q [cfs]
79.8	—	—	—	—	—	—	—	—	—	—						—
80.0	.2	2.69	2	.204	3.24	1	3	—	—	3						3
80.5	.7	2.80	15	.704	3.29	7	22	—	—	22						22
81.0	1.2	3.08	36	1.204	3.34	15	51	1.2	66	51						51
81.5	1.7	3.29	66	1.704	3.39	26	92	1.7	79	79	—	—				79
82.0	2.2	3.3	97	2.204	3.45	40	137	2.2	90	90	.5	2				92
82.5	2.7	3.31	132	2.704	3.50	55	187	2.7	100	100	1.0	6				106
83.0	3.2	3.32	171	3.204	3.55	71	242	3.2	108	108	1.5	10				118
84.2								4.4	127	127	2.7	28	—	—	—	155
85.0								5.2	138	138	3.5	38	.8	2.5	143	319
86.0								6.2	150	150	4.5	50	1.8	2.5	483	683
86.9								7.1	161	161	5.4	57	2.7	2.5	883	1101
88.0								8.2	173	173	6.5	63	3.8	2.5	1482	1718
89.0								9.2	183	183	7.5	69	4.8	2.5	2103	2355

STORCH ENGINEERS

Project 1132-06 BETHANY HOLE DAM

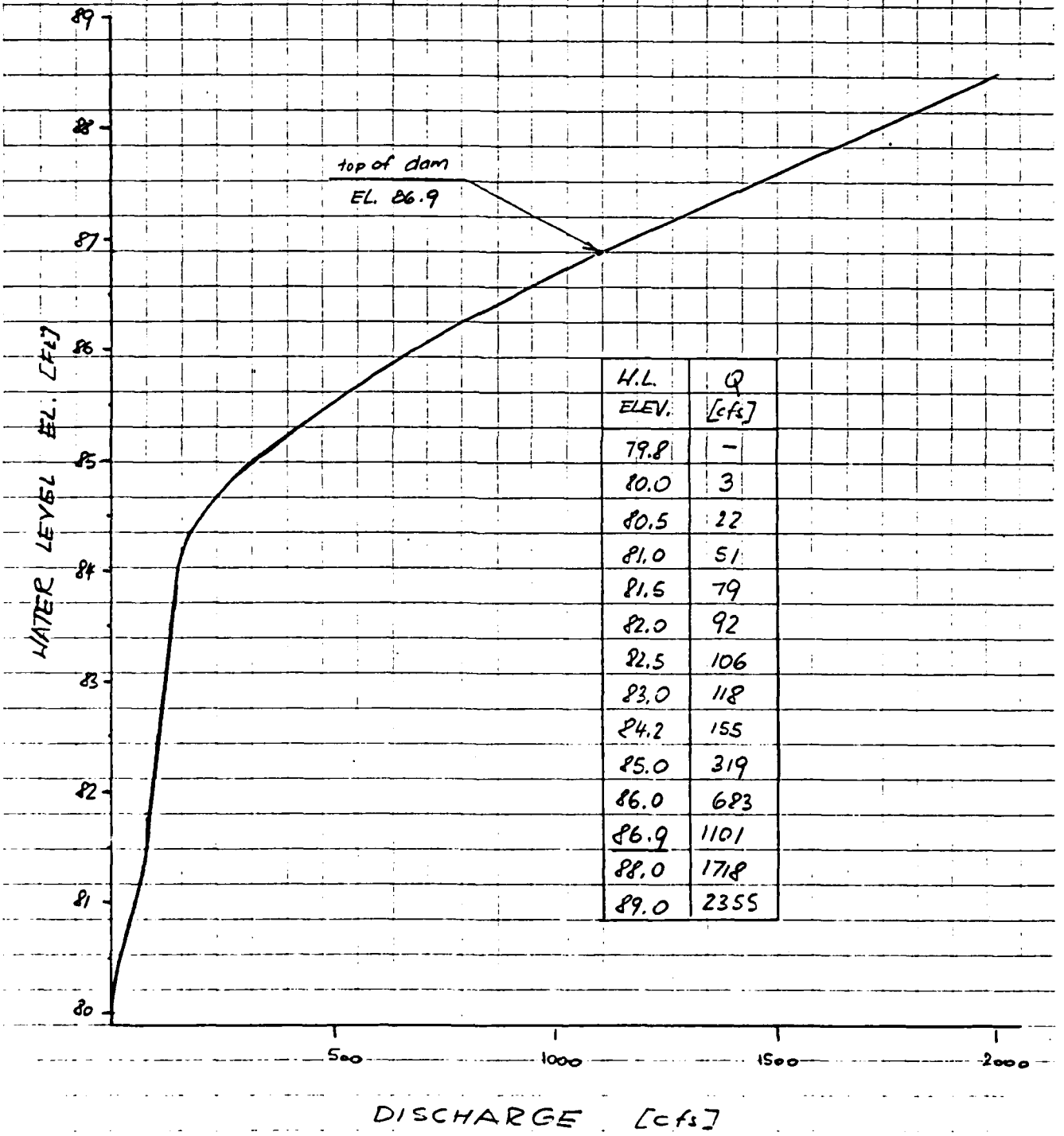
Sheet 11 of 21

Made By JiKa Date 3-19-81

Chkd By JG Date 4/3/81

BETHANY HOLE DAM SPILLWAY

SPILLWAY STAGE - DISCHARGE CURVE



H.L. ELEV.	Q [cfs]
79.8	-
80.0	3
80.5	22
81.0	51
81.5	79
82.0	92
82.5	106
83.0	118
84.2	155
85.0	319
86.0	683
86.9	1101
88.0	1718
89.0	2355

STORCH ENGINEERS

Sheet 12 of 21

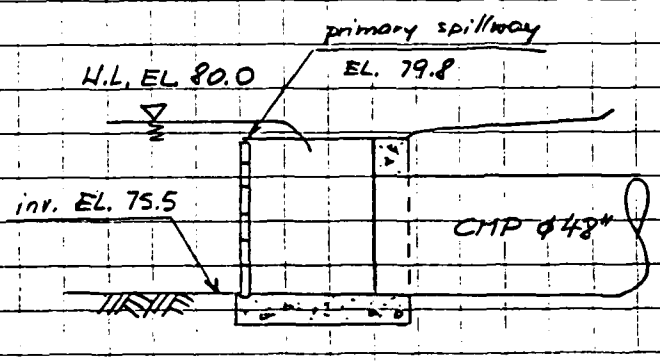
Project 1132 - 06 BETHANY HOLE DAM Made By JiHa Date 3-19-81

Chkd By JG Date 4/3/81

DRAWDOWN

[HCS - Highways Culverts Pg 5-25]

THE DISCHARGE OF DRAWDOWN WILL BE CALCULATED FOR A CMP ϕ 48" INLET CONTROL WITH A HEADWALL



HW = 4.5'

D = 4'

$\frac{HW}{D}$ = 1.125

Nomograph scale (1)

Max. Q = 84.0 cfs

Aver Q = 42.0 cfs.

TIME OF DRAWDOWN

$$Td = \frac{\text{Storage [Acft]}}{\text{Ave. Discharge - Inflow}} \times \frac{43560}{3600}$$

Assume inflow 4.0 cfs

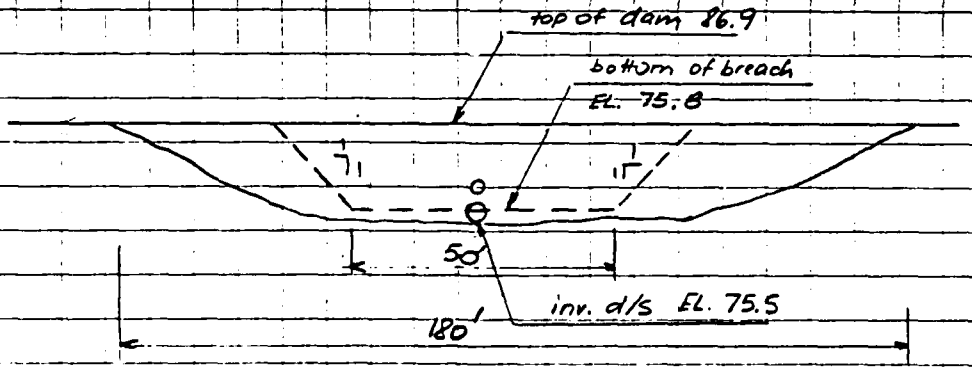
$$Td = \frac{32}{42-4} \times \frac{43560}{3600}$$

Td = 10.2 Hr

BREACH ANALYSIS

A BREACH HYDROGRAPH WILL BE COMPUTED BY THE HEC-1-DAM PROGRAM AND ROUTED THROUGH TWO DOWNSTREAM LAKES (LOST LAKE & VAN DAL LAKE) BY THE MODIFIED PLUS METHOD

BREACH CONDITIONS ARE AS FOLLOWS:



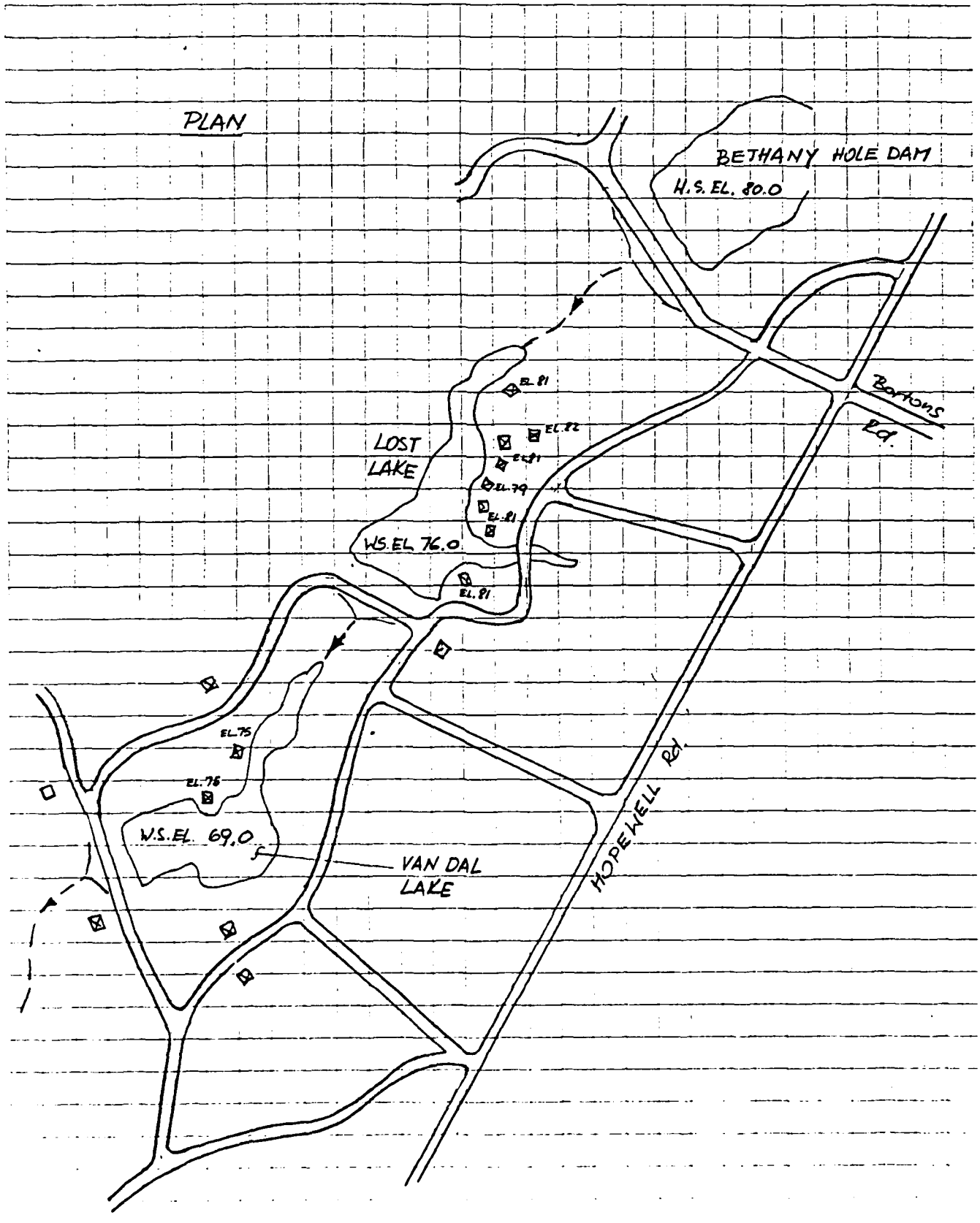
BOTTOM OF BREACH	EFF LENGTH	= 50'	[FT]
	ELEVATION	= 75.8	[FT]
SIDE SLOP OF BREACH		= 1:1	
W.L. ELEVATION		= 80.0	[FT]
W.L ELEV WHICH WILL CAUSE DAM TO FAIL		= 86.9	[FT]
TIME TO DEVELOP BREACH TO MAX. SIZE		= 1.0	[HR]

STORCH ENGINEERS

Sheet 14 of 21

Project 1132-06 BETHANY HOLE DAM Made By JiHa Date 3-20-81

Chkd By JG Date 4/3/81



DOWNSTREAM LAKES ANALYSIS

LOST LAKE:

STORAGE VOLUME

H.L. ELEV. [Ft]	AREA [Acres]
66.8	0
76.0	8.2
80.0	14.6
90.0	78.6

HEC-1-DAM COMPUTER PROGRAM WILL DEVELOP STORAGE CAPACITY FROM WATER SURFACE AREAS & ELEVATIONS.

INFORMATION TAKEN FROM U.S.G.S. QUADRANGLE Medford Lakes, N.J.

HYDRAULICS

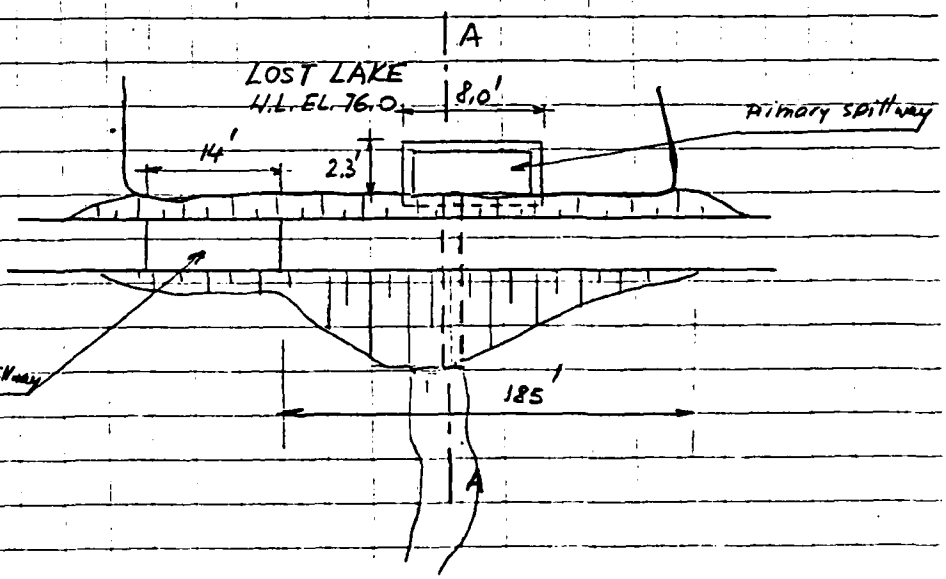
SPILLWAY SECTION

THE SPILLWAY AT THE LOST LAKE DAM CONSISTS OF A PRIMARY SPILLWAY AT ELEV. 75.8 FEET AND A EMERGENCY SPILLWAY AT ELEV. 76.5 FEET

THE PRIMARY SPILLWAY IS A CONCRETE DROP INLET WITH THREE BROAD CRESTED WEIRS

THE EMERGENCY SPILLWAY IS A BROAD CRESTED WEIR OF A TRAPEZIODAL SECTION.

PLAN



STORCH ENGINEERS

Sheet 17 of 21

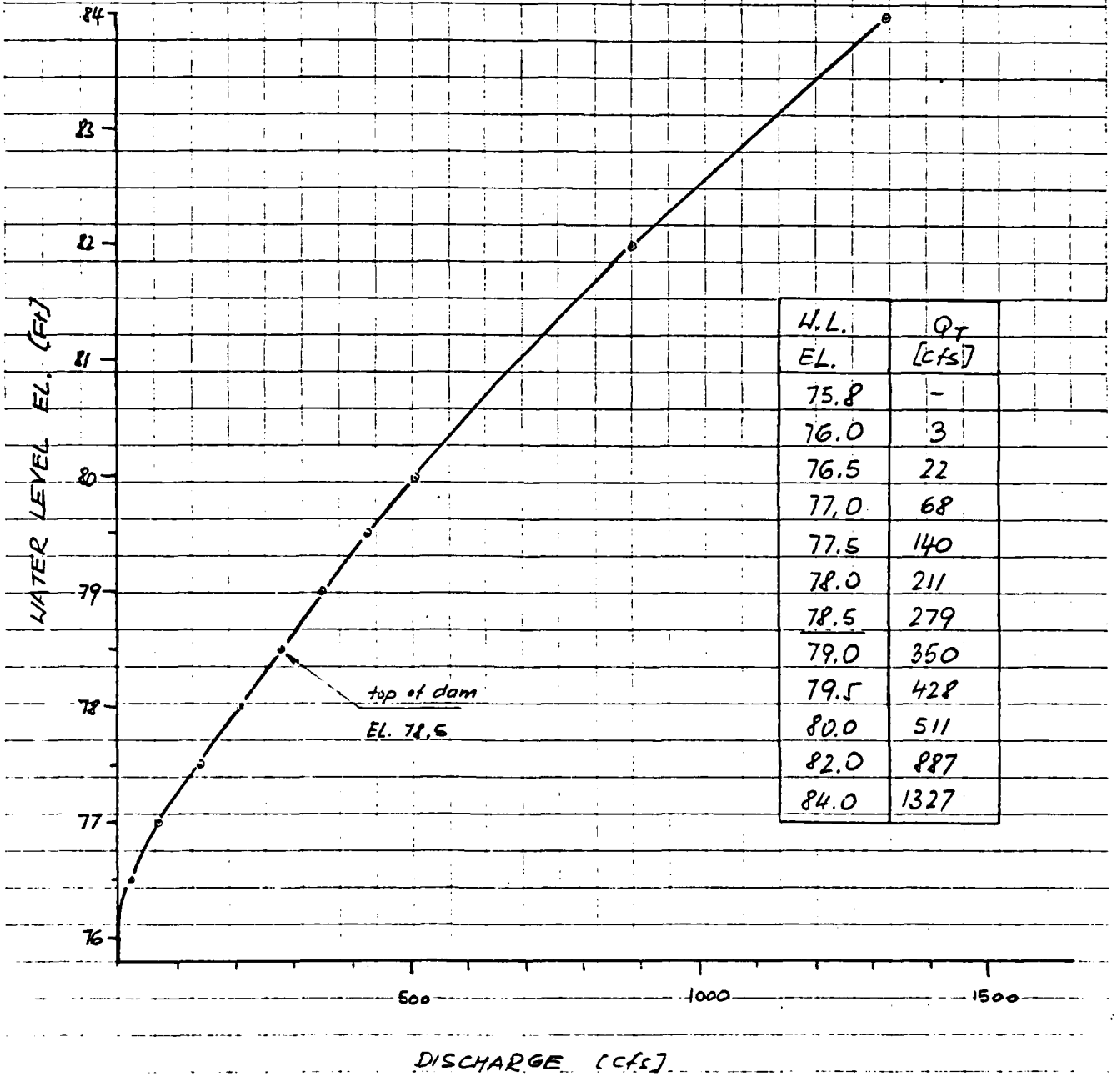
Project 1132-06 BETHEL HOLE DAM (LOST LAKE)

Made By J.HQ Date 3-23-81

Chkd By JG Date 4/3/81

SPILLWAY STAGE DISCHARGE CURVE

(LOST LAKE DAM SPILLWAYS)



W.L. EL.	Q_T [cfs]
75.8	-
76.0	3
76.5	22
77.0	68
77.5	140
78.0	211
78.5	279
79.0	350
79.5	428
80.0	511
82.0	887
84.0	1327

DOWNSTREAM LAKES ANALYSIS

VAN DAL LAKE:

STORAGE VOLUME

W.L. ELEV. [Ft]	AREA [Acres]
62.8	0
69.0	7.3
80.0	20.1
90.0	67.6

HEC-1-DAM COMPUTER WILL DEVELOP STORAGE CAPACITY FROM WATER SURFACE AREAS & ELEVATIONS.

INFORMATION TAKEN FROM U.S.G.S. QUADRANGLE Medford Lakes, N.J.

HYDRAULICS

SPILLWAY SECTION

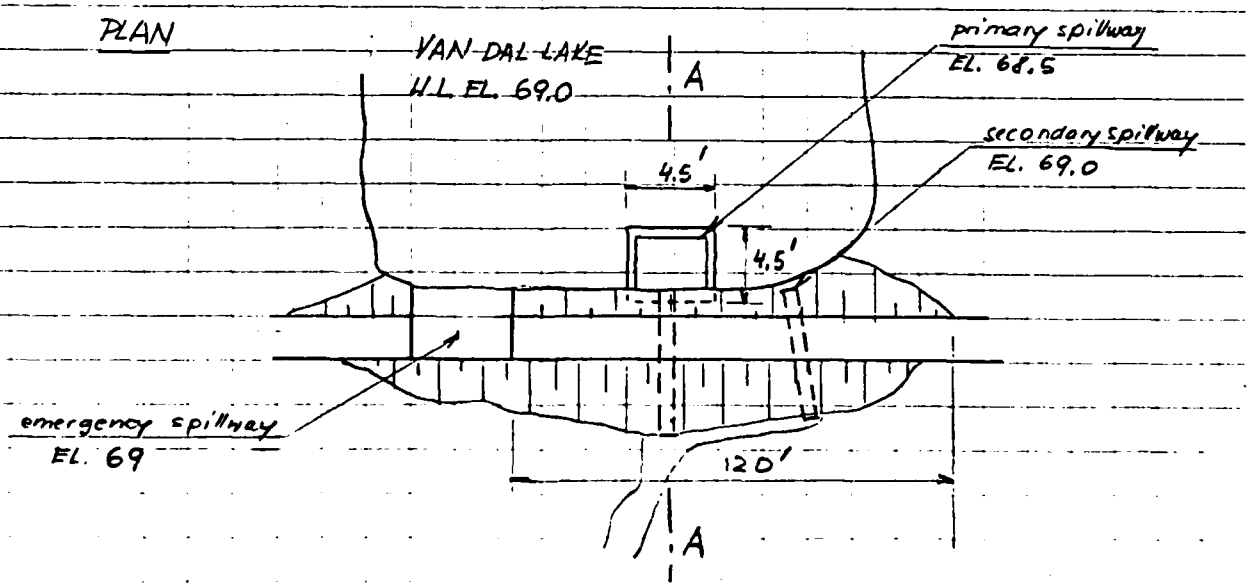
THE SPILLWAY AT THE VAN DAL LAKE DAM CONSISTS OF A PRIMARY SPILLWAY AT EL. 68.5 FEET, A SECONDARY SPILLWAY AT EL. 69.0 FEET AND A EMERGENCY SPILLWAY AT EL. 69.0 FEET.

THE PRIMARY SPILLWAY IS A CONCRETE DROP INLET WITH THREE BROAD CRESTED WEIRS.

THE SECONDARY SPILLWAY IS A CMP ϕ 12"

THE EMERGENCY SPILLWAY IS A BROAD CRESTED WEIR OF A TRAPEZIODAL SECTION

PLAN



STORCH ENGINEERS

Sheet 20 of 21

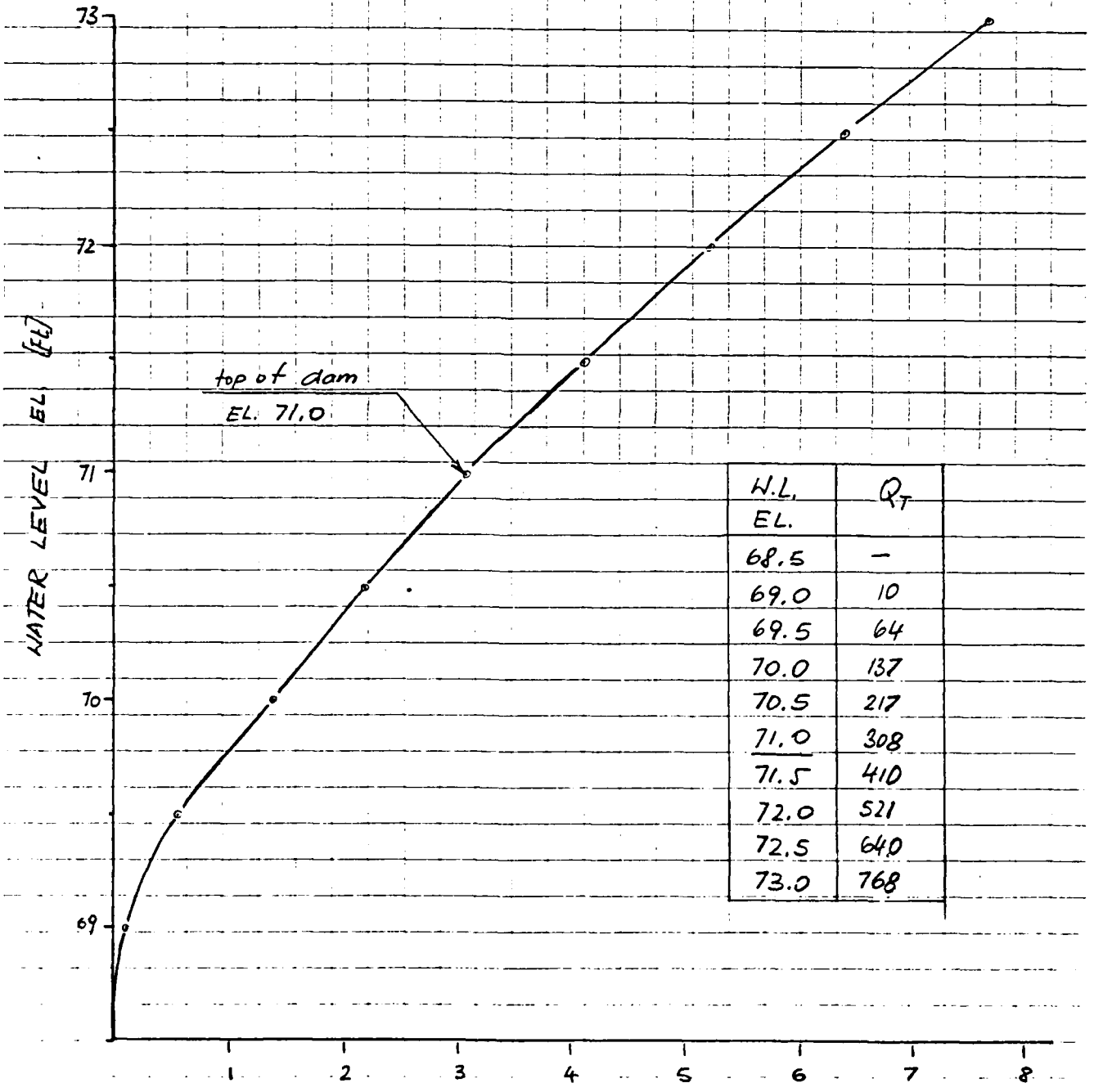
Project 1132-06 BETHANY HOLE DAM (VAN DAL LAKE)

Made By JiHa Date 3-23-81

Chkd By JG Date 4/3/81

SPILLWAY STAGE - DISCHARGE CURVE

(VAN DAL LAKE DAM SPILLWAYS)



W.L. EL.	Q_T
68.5	—
69.0	10
69.5	64
70.0	137
70.5	217
71.0	308
71.5	410
72.0	521
72.5	640
73.0	768

SQUARE 4 X 4 TO THE INCH

BREACH RESULTS;

BETHANY HOLE DAM PEAK OUTFLOW = 3,885 [cfs]

LOST LAKE ; INITIAL W.L. EL. = 76.0 [Ft]

TOP OF DAM EL. = 78.5 [Ft]

MAX. W.L. EL. = 81.7 [Ft]

THE INUNDATION OF A DEWLLING WITH F.F. EL. 79.0 WILL BE APPROX. 2.7 FEET AND THE OVERTOPPING OF DAM WILL BE APPROX. 3.2 FEET.

LOST LAKE DAM PEAK OUTFLOW = 3,608 [cfs]

VAN DAL LAKE: INITIAL W.L. EL. = 69.0 [Ft]

TOP OF DAM EL. = 71.0 [Ft]

MAX. W.L. EL. = 74.7 [Ft]

THE OVERTOPPING OF DAM WILL BE APPROX. 3.7 FEET

HEC - 1 - DAM PRINTOUT

Overtopping Analysis

```
1A1                          NATIONAL DAM SAFETY PROGRAM
A2                           BETHANY HOLE DAM, NEW JERSEY
A3                            100 YEAR STORM ROUTING
B     300        0       15                                                  4
R1      5
J       1        1        1
J1      1
K       0   BEHOL                                          1
K1                        INFLOW HYDROGRAPH TO BETHANY HOLE DAM
M       0        2      2.5              2.5                                1
O      96
O1  0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019
O1  0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019
O1  0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019
O1  0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019
O1  0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.038    0.038
O1  0.038    0.038    0.038    0.038    0.038    0.038    0.038    0.038    0.038    0.038
O1  0.083    0.083    0.083    0.083    0.163    0.163    0.163    0.163    0.750    0.750
O1  0.750    0.750    0.163    0.163    0.163    0.163    0.083    0.083    0.083    0.083
O1  0.083    0.083    0.083    0.083    0.038    0.038    0.038    0.038    0.038    0.038
O1  0.038    0.038    0.038    0.038    0.038    0.038
T                                                        1.5     0.15
W2              1.9
X    -1.0    -0.05     2.0
K       1     DAM
K1                        ROUTE DISCHARGE THROUGH BETHANY HOLE DAM
Y                                        1        1
Y1                                                       -80.0       -1
Y4   79.8     80.0     80.5     81.0     81.5     82.0     82.5     83.0     84.2     85.0
Y4   86.0     86.9     88.0     89.0
Y5      0        3       22       51       79       92      106      118      155      319
Y5    683     1101     1718     2355
$A      0     21.1     26.6    260.0
$E   75.5     80.0     90.0    100.0
$$   79.8
$D   86.9      2.7      1.5      180
K       1   LO-DAM
K1                        ROUTE DISCHARGE THROUGH LOST LAKE DAM
Y                                        1        1
Y1      1                                                -76.0       -1
Y4   75.8     76.0     76.5     77.0     77.5     78.0     78.5     79.0     79.5     80.0
Y4   82.0     84.0
Y5      0        3       22       68      140      211      279      350      428      511
Y5    887     1327
$A      0      8.2     14.6     78.6
$E   66.8     76.0     80.0     90.0
$$   75.8
$D   78.5      2.7      1.5      185
K       1   VA-DAM
K1                        ROUTE DISCHARGE THROUGH VAN DAL LAKE DAM
Y                                        1        1
Y1      1                                                -69.0       -1
Y4   68.5     69.0     69.5     70.0     70.5     71.0     71.5     72.0     72.5     73.0
Y5      0       10       64      137      217      308      410      521      640      768
$A      0      7.3     20.1     62.6
$E   62.8     69.0     80.0     90.0
$$   68.5
$D   71.0      2.7      1.5      120
K      99
```

NATIONAL DAM SAFETY PROGRAM
BETHANY HOLE DAM, NEW JERSEY
100 YEAR STORM ROUTING

JOB SPECIFICATION

NO	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	15	0	0	0	0	0	4	0

JOPER	NWT	LROPT	TRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 1 LRTIO= 1
RTIOS= 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO BETHANY HOLE DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	JAUTO
BENOL	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	2	2.50	0.00	2.50	0.00	0.000	0	1	0

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.50	.15	0.00	0.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= 1.90

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 2.00

0
END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	7.12	4.33	2.79	28960.
										(181.)	(110.)	(71.)	(820.06)

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE DISCHARGE THROUGH BETHANY HOLE DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
DAM	1	0	0	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
0	0	0	0.000	0.000	0.000	-80.	-1

STAGE	79.80	80.00	80.50	81.00	81.50	82.00	82.50	83.00	84.20	85.00
	86.00	86.90	88.00	89.00						
FLOW	0.00	3.00	22.00	51.00	79.00	92.00	106.00	118.00	155.00	319.00
	683.00	1101.00	1718.00	2355.00						
SURFACE AREA=	0.	21.	27.	260.						
CAPACITY=	0.	32.	270.	1502.						
ELEVATION=	76.	80.	90.	100.						

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
79.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

IOPEL	COOD	EXPD	DAMWID
86.9	2.7	1.5	180.

PEAK OUTFLOW IS 1866. AT TIME 20.00 HOURS

OPERATION	STATION	AREA	PLAN	RATIO 1 1.00
HYDROGRAPH AT	BEHOL	2.50 (6.47)	1	2023. (57.28)
ROUTED TO	DAM	2.50 (6.47)	1	1866. (52.84)
ROUTED TO	LO-DAM	2.50 (6.47)	1	1831. (51.85)
ROUTED TO	VA-DAM	2.50 (6.47)	1	1793. (50.78)

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	80.00	79.80	86.90
STORAGE	32.	28.	190.
OUTFLOW	3.	0.	1101.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	87.67	.77	209.	1866.	2.00	20.00	0.00

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	76.00	75.80	78.50
STORAGE	25.	24.	50.
OUTFLOW	3.	0.	279.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	80.33	1.85	75.	1831.	5.50	20.25	0.00

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	69.00	68.50	71.00
STORAGE	15.	12.	32.
OUTFLOW	10.	0.	308.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	73.11	2.11	53.	1793.	5.25	20.50	0.00

HEC - 1 - DAM PRINTOUT

Breach Analysis

```
1A1                          NATIONAL DAM SAFETY PROGRAM
A2                           BETHANY HOLE DAM, NEW JERSEY
A3                            100 YEAR STORM ROUTING
B     300        0        15                                                  4
B1      5
J       1        1        1
J1      1
K       0   BEHOL                                          1
K1                    INFLOW HYDROGRAPH TO BETHANY HOLE DAM
M       0        2      2.5              2.5                                 1
O       96
O1  0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019
O1  0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019
O1  0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019
O1  0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.019    0.038    0.038
O1  0.038    0.038    0.038    0.038    0.038    0.038    0.038    0.038    0.038    0.038
O1  0.083    0.083    0.083    0.083    0.163    0.163    0.163    0.163    0.750    0.750
O1  0.750    0.750    0.163    0.163    0.163    0.163    0.083    0.083    0.083    0.083
O1  0.083    0.083    0.083    0.083    0.038    0.038    0.038    0.038    0.038    0.038
O1  0.038    0.038    0.038    0.038    0.038    0.038
I                                                      1.5     0.15
W2                    1.9
X    -1.0    -0.05     2.0
K       1       DAM
K1                    ROUTE DISCHARGE THROUGH BETHANY HOLE DAM
Y                                      1        1
Y1                                                      -80.0       -1
Y4  79.8     80.0     80.5     81.0     81.5     82.0     82.5     83.0     84.2     85.0
Y4  86.0     86.9     88.0     89.0
Y5     0        3       22       51       79       92      106      118      155      319
Y5   683     1101     1718     2355
$A     0     21.1     26.6    260.0
$E  75.5     80.0     90.0    100.0
$$  79.8
$D  86.9      2.7      1.5      180
$B    50        1     75.8      1.0       80     87.2
K       1   LO-DAM
K1                    ROUTE DISCHARGE THROUGH LOST LAKE DAM
Y                                      1        1
Y1      1                                               -76.0       -1
Y4  75.8     76.0     76.5     77.0     77.5     78.0     78.5     79.0     79.5     80.0
Y4  82.0     84.0
Y5     0        3       22       68      140      211      279      350      428      511
Y5   887     1327
$A     0      8.2     14.6     78.6
$E  66.8     76.0     80.0     90.0
$$  75.8
$D  78.5      2.7      1.5      185
K       1   VA-DAM
K1                    ROUTE DISCHARGE THROUGH VAN DAL LAKE DAM
Y                                      1        1
Y1      1                                               -69.0       -1
Y4  68.5     69.0     69.5     70.0     70.5     71.0     71.5     72.0     72.5     73.0
Y5     0       10       64      137      217      308      410      521      640      768
$A     0      7.3     20.1     67.6
$E  62.8     69.0     80.0     90.0
$$  68.5
$D  71.0      2.7      1.5      120
K      99
```

NATIONAL DAM SAFETY PROGRAM
BETHANY HOLE DAM, NEW JERSEY
100 YEAR STORM ROUTING

JOB SPECIFICATION

NQ	NHR	NMIN	IDAY	IHR	IMIN	METRC	IPLT	IPRT	NSTAN
300	0	15	0	0	0	0	0	4	0

JOPER	NWT	LROPT	IRACE
5	0	0	0

MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NRTIO= 1 LRTIO= 1

RTIOS= 1.00

********** ********** ********** ********** **********

SUB-AREA RUNOFF COMPUTATION

INFLOW HYDROGRAPH TO BETHANY HOLE DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
BEHOL	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

IHYDG	IUHG	TAREA	SNAP	TRSDA	TRSPC	RATIO	ISNOW	ISAME	LOCAL
0	2	2.50	0.00	2.50	0.00	0.000	0	1	0

LOSS DATA

LROPT	STRKR	DLTKR	RTIOL	ERAIN	STRKS	RTIOK	STRTL	CNSTL	ALSMX	RTIMP
0	0.00	0.00	1.00	0.00	0.00	1.00	1.50	.15	0.00	0.00

UNIT HYDROGRAPH DATA
TC= 0.00 LAG= 1.90

RECESSION DATA
STRTQ= -1.00 QRCSN= -.05 RTIOR= 2.00

0
END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
									SUM	7.12	4.33	2.79	28960.
										(181.)(110.)(71.)(			820.06)

********** ********** ********** ********** **********

HYDROGRAPH ROUTING

ROUTE DISCHARGE THROUGH BETHANY HOLE DAM

ISTAO	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
DAM	1	0	0	0	0	0	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
0.0	0.000	0.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
0	0	0	0.000	0.000	0.000	-80.	-1

STAGE	79.80	80.00	80.50	81.00	81.50	82.00	82.50	83.00	84.20	85.00
	86.00	86.90	88.00	89.00						
FLOW	0.00	3.00	22.00	51.00	79.00	92.00	106.00	118.00	155.00	319.00
	683.00	1101.00	1718.00	2355.00						
SURFACE AREA=	0.	21.	27.	260.						
CAPACITY=	0.	32.	270.	1502.						
ELEVATION=	76.	80.	90.	100.						

CREL	SPWID	COOW	EXPW	ELEVL	COOL	CAREA	EXPL
79.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAM DATA

TOPEL	COOD	EXPD	DAMWID
86.9	2.7	1.5	180.

DAM BREACH DATA

BRWID	Z	ELBM	TFAIL	WSEL	FAILEL
50.	1.00	75.80	1.00	80.00	87.20

BEGIN DAM FAILURE AT 19.50 HOURS

PEAK OUTFLOW IS 3885. AT TIME 20.50 HOURS

OPERATION	STATION	AREA	PLAN	RATIO 1
				1.00
HYDROGRAPH AT	BEHOL	2.50	1	2023.
		(6.47)		(57.28)(
ROUTED TO	DAM	2.50	1	3885.
		(6.47)		(110.02)(
ROUTED TO	LO-DAM	2.50	1	3608.
		(6.47)		(102.18)(
ROUTED TO	VA-DAM	2.50	1	3463.
		(6.47)		(98.06)(

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	80.00	79.80	86.90
STORAGE	32.	28.	190.
OUTFLOW	3.	0.	1101.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	87.37	.47	202.	3885.	.67	20.50	19.50

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	76.00	75.80	78.50
STORAGE	25.	24.	50.
OUTFLOW	3.	0.	279.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	81.65	3.15	100.	3608.	4.50	20.50	0.00

1 SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 .....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	69.00	68.50	71.00
STORAGE	15.	12.	32.
OUTFLOW	10.	0.	308.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	74.66	3.66	72.	3463.	4.50	20.75	0.00

APPENDIX 5

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